Commercial Flight Systems Group
Business and Commuter Aviation Systems Division
Honeywell Inc.
Box 29000
Phoenix, Arizona 85038

PRIMUS 650
COLORADAR System

System Description and Installation Manual

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INTRODUCTION

This technical manual provides information for the installation, operation, and maintenance of the PRIMUS® 650 COLORADAR™ system. The maintenance instructions are suitable for use by line-maintenance personnel while the aircraft is on the ground. For servicing instructions normally performed by shop personnel after the equipment has been removed from the aircraft, refer to the applicable maintenance manuals listed below:

PRIMUS® 650 UNIT	COMPONENT MAINTENANCE MANUAL
WI-450 and WI-650 Indicator	A09-3940-01
WU-450 and WU-650 Receiver-Transmitter-Antenna	A09-3941-02
WC-650 Controller and Miscellaneous Items	A09-3941-03

The system is manufactured by Honeywell Inc., Business and Commuter Aviation Systems Division, Glendale, Arizona.

The following is a list of abbreviations used throughout this manual.

Abbreviation	Equivalent
AZ	Azimuth
CLR TST	Clear Test (LSS)
CONTR	Controller
CTR	Counter
DISP	Display
EFIS	Electronic Flight Instrument System
EHSI	Electronic Horizontal Situation Indicator
EL	Elevation
FP/FLT PLN	Flight Plan
FSB	Forced Standby
GMAP	Ground Map
INDPS	Indicator Power Supply
LSS	Lightning Sensor System
LX	Lightning Detection
MDS	Minimum Discernible Signal
MFD	Multi-Function Display
MPEL	Maximum Permissible Exposure Level
MUX	Multiplexer
NM	Nautical Mile
NTC	Neck Twist Coil
POR	Power on Reset
PRF	Pulse Repetition Frequency
PW	Pulse Width
RCT/REACT	Rain Echo Attenuation Compensation Technique
RNG	Range
RTA	Receiver-Transmitter-Antenna

Abbreviation	Equivalent
SCI	Serial Control Interface
SLV	Slave
STAB	Stabilization
STC	Sensitivity Time Control
STBY	Standby
TR	Transmitter-Receiver
TST	Test
UART	Universal Asynchronous Receiver-Transmitter
UDI	Universal Digital Interface
VAR	Variable
WX	Weather
WXPD	Weather Picture Data
XSTC	Extended Sensitivity Time Control

SECTION 1

DESCRIPTION

A. GENERAL

The line replaceable units (LRU) of the PRIMUS® 650 COLORADAR system are shown in Figure 1-1. This system makes up a lightweight, two-box, X-band alphanumeric digital radar with display designed for weather location and analysis, and for ground mapping. The radar system can be operated in conjunction with Electronic Flight Instrument System (EFIS) and Multi-Function Display (MFD) equipment to provide radar video to the EFIS and MFD.

The dedicated radar Indicator can also be operated in conjunction with DATA NAV and Lightning Sensor Systems.

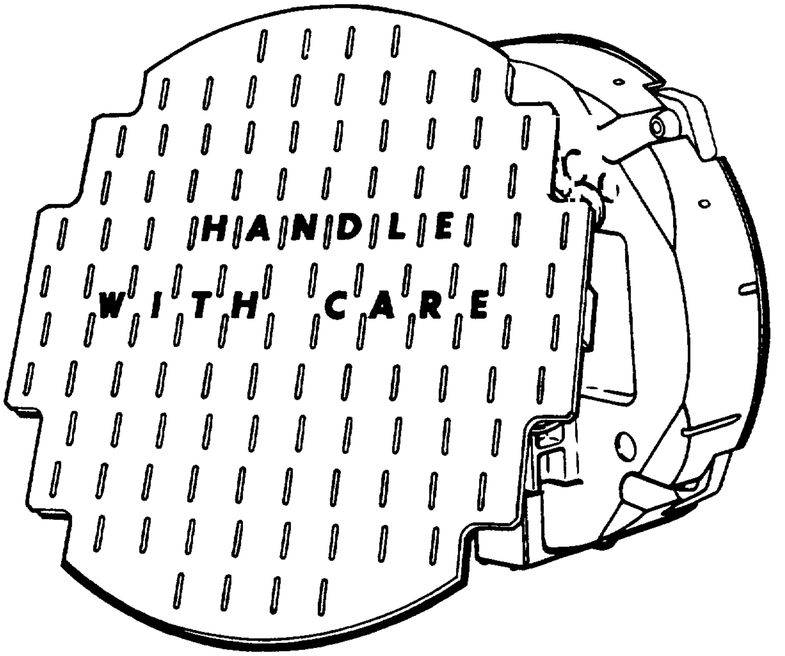
B. PURPOSE OF SYSTEM

This radar system detects storms along the flight path of the aircraft and gives the pilot a visual indication, in color, of storm intensity. In weather detection mode, target returns are displayed at one of five video levels (0, 1, 2, 3, or 4), with 0 represented by a black screen because of weak or no returns, and levels 1, 2, 3, and 4 represented by green, yellow, red, and magenta to show progressively stronger returns. In ground-mapping mode, video levels of increasing reflectivity are displayed as black, cyan, yellow, and magenta.

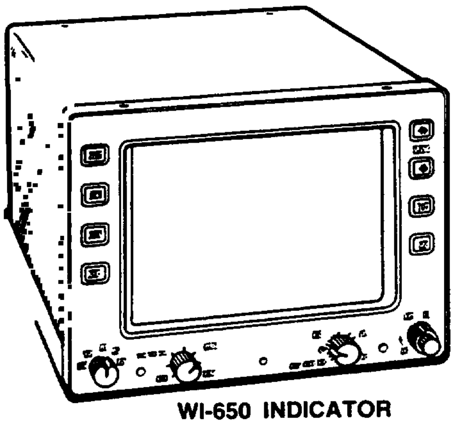
C. SYSTEM CONFIGURATIONS

Some configurations in which the PRIMUS® 650 system is operated with and without EFIS and MFD are shown in Figure 1-2.

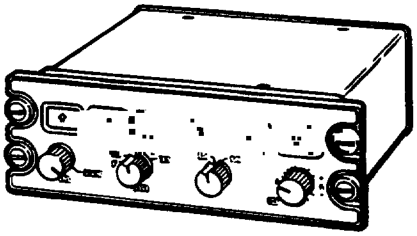
WARNING: THE SYSTEM PERFORMS ONLY THE FUNCTIONS OF WEATHER DETECTION AND GROUND MAPPING. IT SHOULD NOT BE USED NOR RELIED UPON FOR PROXIMITY WARNING, ANTICOLLISION, OR TERRAIN AVOIDANCE.



WU-650 RTA



WI-650 INDICATOR



WC-650 CONTROLLER

AD-9685-R3

PRIMUS® 650 Units
Figure 1-1

Type	Configuration	Type of Operation	Indicator Display (Center WX Disp)	Left EFIS	Right EFIS	MFD	Left Contr	Right Contr
1	Stand-Alone WX	Single	X					
2	Radar Display and Single EFIS	Single	X	X				
3	Radar Display and Dual EFIS	Single	X	X	X			
4	Dual EFIS and (No Indicator Display)	Single		X	X		X or	X
5	Single EFIS and MFD	Single		X		X	X or	X
6	Dual EFIS and MFD	Single		X	X	X	X or	X
7	Dual EFIS and (No Center Display)	Dual		X	X		X	X
8	Dual EFIS and MFD	Dual		X	X	X (Note 1)	X	X

NOTES: 1. MFD can display either left or right radar data (switch, on MFD, is selectable)

2. In the following sheets of this figure:

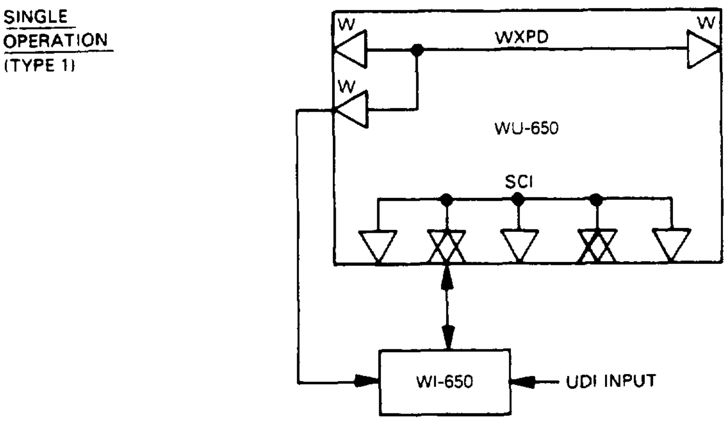
—⋈— denotes bidirectional (UART) serial control bus SCI port

—◁— denotes unidirectional (buffer) serial control bus SCI port

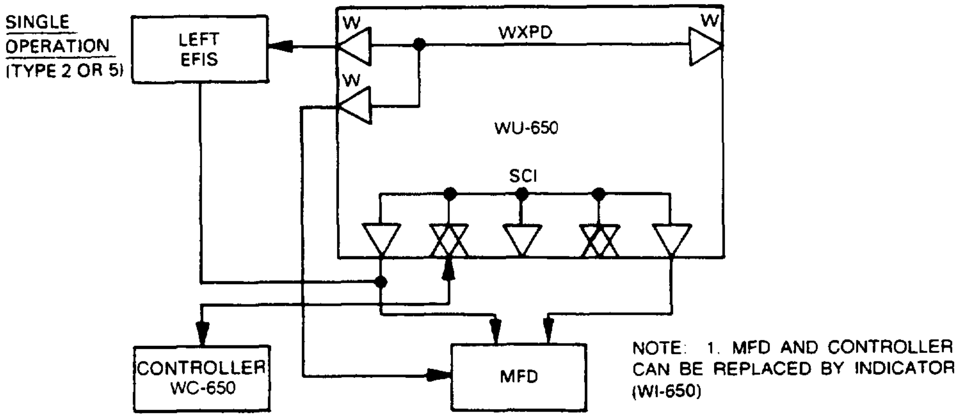
—◁— (W) denotes serial weather bus WXPD port

AD-9273

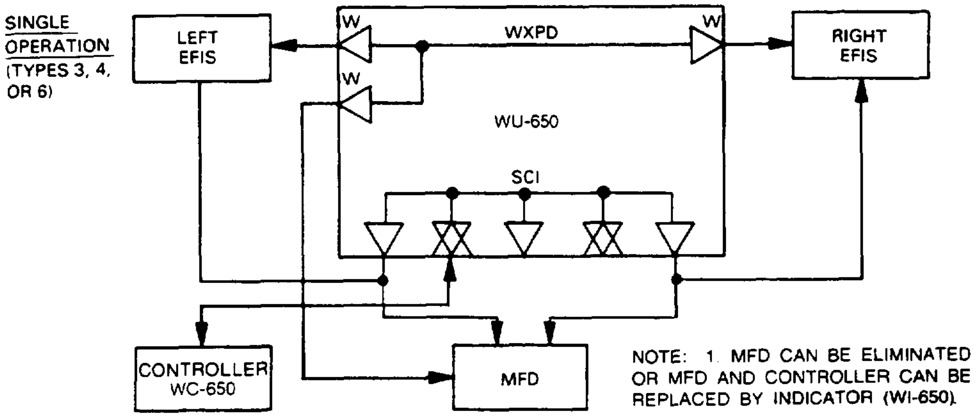
Some PRIMUS® 650 System Configurations
Figure 1-2 (Sheet 1 of 3)



STAND-ALONE WX


SINGLE OPERATION (TYPE 2 OR 5)
LEFT EFIS
W
WXPD
W
W
WU-650
SCI
CONTROLLER WC-650
MFD
NOTE: 1. MFD AND CONTROLLER CAN BE REPLACED BY INDICATOR (WI-650)

SINGLE EFIS, MFD, SINGLE CONTROLLER

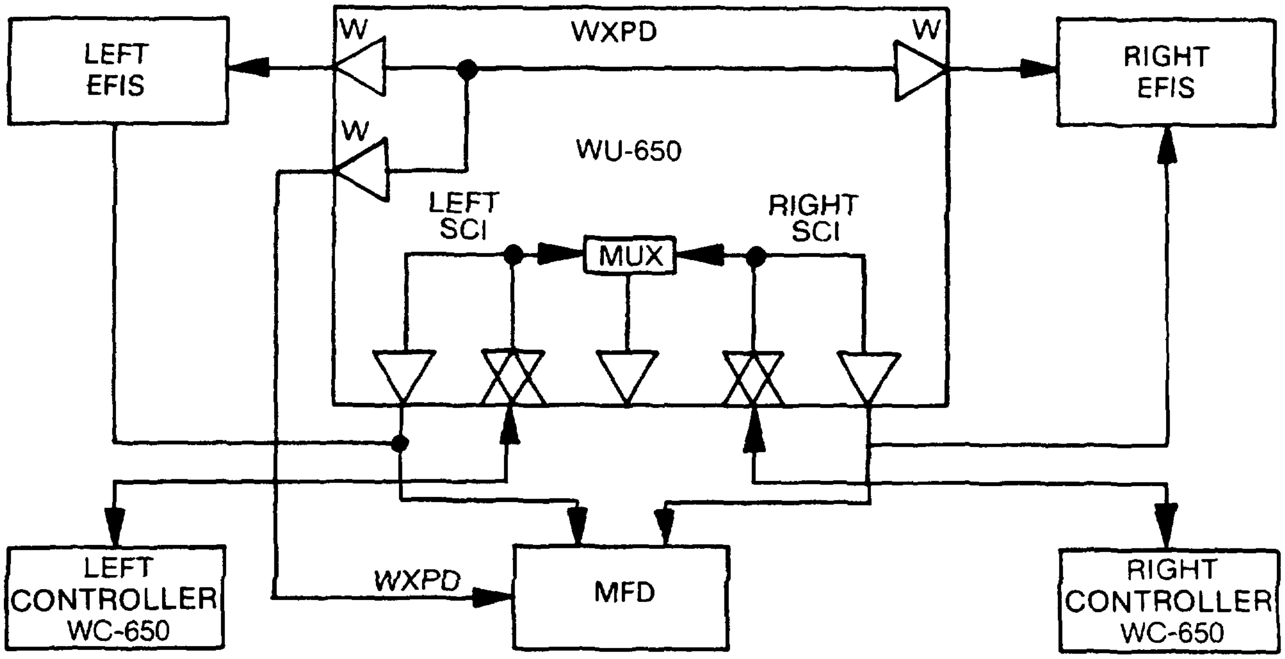

SINGLE OPERATION (TYPES 3, 4, OR 6)
LEFT EFIS
W
WXPD
W
RIGHT EFIS
W
WU-650
SCI
CONTROLLER WC-650
MFD
NOTE: 1. MFD CAN BE ELIMINATED OR MFD AND CONTROLLER CAN BE REPLACED BY INDICATOR (WI-650).

DUAL EFIS, MFD, SINGLE CONTROLLER

AD-9868-R1

Some PRIMUS® 650 System Configurations
Figure 1-2 (Sheet 2)

DUAL
OPERATION
(TYPES 7, 8)



DUAL EFIS, MFD, DUAL CONTROLS

NOTES:

1. MFD CAN DISPLAY EITHER LEFT OR RIGHT DATA.
2. CAN BE USED WITHOUT MFD.

AD-9869-R1

Some PRIMUS® 650 System Configurations
Figure 1-2 (Sheet 3)

D. DESCRIPTION OF UNITS

The units that make up the system are described below.

1. Receiver-Transmitter-Antenna

The Receiver-Transmitter-Antenna (RTA), is an integrated unit which incorporates transmitter, receiver, and antenna into a single unit. The RTA accepts either a 12-inch or 10-inch flat-plate radiator with transmitter and receiver components mounted on the rear of the antenna. The remainder of the circuitry is contained in the electronics package which forms the RTA base. The RTA is designed for cantilever mounting on the front bulkhead of the aircraft.

2. Indicator

The Indicator contains a complete set of system operating controls and is used in systems without Controllers. The Indicator is available in two bezel colors, gray and black.

The Indicator is designed for instrument-panel mounting. Target inputs are displayed on a rectangular 5-inch CRT together with range and mode alphanumerics to facilitate evaluation of the picture. Front panel lighting at 5 V ac/dc or 27.5 V dc is determined by wiring to the Indicator. The major assemblies of the Indicator are the low voltage power supply, high voltage power supply, weather interface, video and deflection, alphanumerics generator, SCI transceiver, timing generator, and front panel controls.

3. Controller

The Controller contains all controls necessary for operating the radar system. The Controller is for use in installations which do not include a dedicated radar Indicator. Controller lighting is 28 V dc or 5 V ac/dc.

E. EQUIPMENT SUPPLIED BY HONEYWELL

1. PRIMUS® 650 System Components

PRIMUS® 650 System Components supplied by Honeywell are listed in Table 1-1.

Component/Part No.		Description								
		VIBRATION CATEGORY	FLAT-PLATE ANTENNA SIZE (INCH)	ARINC 429 STAB	ANALOG STAB	WEIGHT (LBS)	SUPPRESSOR OUTPUT	OUTLINE AND INSTALLATION DIAGRAM	BEZEL COLOR	KNOBS COLOR
RTA WU-650	7008470-901	CM	10	--	Yes	13.0	--	6-1	--	--
RTA WU-650	7008470-902	CM	12	--	Yes	13.0	--	6-1	--	--
RTA WU-650	7008470-911	JL	10	--	Yes	13.5	--	6-1	--	--
RTA WU-650	7008470-912	JL	12	--	Yes	13.5	--	6-1	--	--
RTA WU-650	7008470-921	JL	10	Yes	Yes	13.5	--	6-1	--	--
RTA WU-650	7008470-922	JL	12	Yes	Yes	13.5	--	6-1	--	--
RTA WU-650	7008470-721	JL	10	Yes	Yes	13.5	Yes	6-1	--	--
RTA WU-650	7008470-722	JL	12	Yes	Yes	13.5	Yes	6-1	--	--
INDICATOR WI-650	7007700-301	PKS	--	--	--	12.0	--	6-2	Gray	Black
INDICATOR WI-650	7007700-302	PKS	--	--	--	12.0	--	6-2	Black	Black
INDICATOR WI-650	7007700-303	PKS	--	--	--	10.0	--	6-2	Gray	Black
INDICATOR WI-650	7007700-304	PKS	--	--	--	10.0	--	6-2	Black	Black
CONTROLLER WC-650	7008471-201	KS	--	--	--	1.9	--	6-3	Gray	Black
CONTROLLER WC-650	7008471-202	KS	--	--	--	1.9	--	6-3	Black	Black
CONTROLLER WC-650	7008471-203	KS	--	--	--	1.9	--	6-3	Gray	Black
CONTROLLER WC-650	7008471-204	KS	--	--	--	1.9	--	6-3	Black	Black
CONTROLLER WC-650	7008471-601	KS	--	--	--	1.9	--	6-3	Gray	Black
CONTROLLER WC-650	7008471-602	KS	--	--	--	1.9	--	6-3	Black	Black
CONTROLLER WC-650	7008471-603	KS	--	--	--	1.9	--	6-3	Gray	Gray
CONTROLLER WC-650	7008471-604*	KS	--	--	--	1.9	--	6-3	Gray	Black
CONTROLLER WC-650	7008471-605	KS	--	--	--	1.9	--	6-3	Gray	Black
CONTROLLER WC-650	7008471-606	KS	--	--	--	1.9	--	6-3	Black	Black
CONTROLLER WC-650	7008471-607	KS	--	--	--	1.9	--	6-3	Gray	Black
CONTROLLER WC-650	7008471-608	KS	--	--	--	1.9	--	6-3	Black	Black
MOUNTING TRAY	7011359-901	--	--	--	--	0.4	--	6-2	--	--
CONTROLLER WC-650	7008471-622	KS	--	--	--	1.9	--	6-3	Black	Black

* Minimum Range 25 NM

PRIMUS® 650 System Components
Table 1-1

E. 2. Alternate Display Systems

The components listed in Table 1-1 are all subject to TSO approval. The PRIMUS® 650 equipment is also designed to use the radar display capabilities of various alternate display systems for the purpose of displaying radar data.

The PRIMUS® 650 radar system operating in conjunction with such alternate display systems is considered to be TSO approved provided the alternate display system meets the following requirements:

(a) The alternate display system concerned is designed and certified to conform to Sperry Specification 7007412 (Radar/EFIS interfacing specifications).

(b) The alternate display system is qualified and approved to the appropriate parts of TSO C63.

(c) The installation documentation for the alternate display system adequately specifies the equipment required to provide such a radar display and conform to steps (a) and (b) above.

Alternate display systems which meet the above qualifications at the date of this revision are listed in Table 1-2. Note that this does not forbid the use of qualified alternate display systems which may be introduced in the future.

Component Designation	Part No.	Description	Weight (Pounds)	Outline and Installation Reference Drawing
SG-603	7003400-603	Analog Symbol Generator (5x5 display)	17.0	EB7004898
SG-802	7003400-802	Analog Symbol Generator (5x6 display)	17.0	EB7011059
SG-803	7003400-803	Analog Symbol Generator (5x6 display)	17.0	EB7004898
SG-611	7004544-611	Digital Symbol Generator (5x5 display)	16.0	PS7008357
SG-811	7004544-811	Digital Symbol Generator (5x6 display)	16.0	PS7008357
MG-603	7007061-603	Multifunction Display Generator (5x5 display)	21.0	PS7010233
MG-803	7007061-803	Multifunction Display Generator (5x6 display)	21.0	PS7010233

Alternate Display Systems
Table 1-2

E. 3. Connector Kits

The connector kits are described in Table 1-3.

Part No.	Description
7011070-001, -911	Connector kit for radar system with dedicated radar Indicator.
7011070-002, -912	Connector kit is the same as -001, except it includes UDI* connector.
7011070-003, -913	Connector kit for radar system with single Controller and no dedicated radar Indicator.
7011070-004	Connector kit for radar system with dual Controllers and no dedicated radar Indicator.

*NOTE: DATA NAV Connector kits include this connector.

Connector Kits
Table 1-3

F. SYSTEM CAPABILITIES AND LIMITATIONS

Capabilities and limitations of the systems are provided in Table 1-4.

Antenna	
Size:	10-inch or 12-inch flat-plate antenna
Stabilization:	Line-of-sight, ±30 degrees (combined Pitch/Roll & Tilt)
Stabilization input type	ARINC 407, 2-wire, 400 Hz (Pitch and Roll) or ARINC 429, 2-wire, serial bus**
Stabilization input slope	50 millivolts or 200 millivolts per degree* (Pin programmable)
Stabilization input impedance	10k ohms
Stabilization accuracy	±1.0 degree @ 20 degrees (Excluding errors outside of the PRIMUS, 650 system)
Tilt:	±15 degrees
Scan:	Full - 120 degrees (±60 degrees) Sector - 60 degrees (±30 degrees)
Roll Axis Trim: (Hidden Mode)	Refer to paragraph D.5. of Section 7 in this manual
Gain:	10-inch - 26 dB 12-inch - 28 dB
Beam Width:	10-inch flat-plate radiator - 9.5 degrees 12-inch flat-plate radiator - 7.9 degrees
Scan Rate:	13.5 ± 1 looks/min (120 degree scan, single control)

NOTES: *These voltages are defined as: E/2300 ± 2% (50 millivolts/degree) or E/575 ± 2% (200 millivolts/degree) where E is the actual voltage of the 115 V, 400 Hz supply.

**In Part No. 7008470-721, -722, -921 and -922, either analog or digital input stabilization is possible, but not both simultaneously.

Capabilities and Limitations
Table 1-4

Transmitter	
Frequency:	9345 ± 25 MHz NOTE: The PRIMUS® 650 will confine 99% of its emitted power to a frequency band from 9320 to 9370 MHz.
Power:	1.3 kW, nominal, magnetron
Pulse Widths:	1.2, 1.5, 2.4, 4.8, 9, and 18 usec, determined by selected range
PRF:	120, 240, 360, and 480 Hz, determined by selected range
Suppression Pulse:	-721 and -722
Amplitude	5 volts nominal, 4.5 volts minimum into 500
Pulse Width	Minimum 200 nanoseconds before leading edge of transmitter pulse to minimum 200 nanoseconds after trailing edge of transmitter pulse

Receiver	
Noise Figure:	8.5 dB, typical
IF (Intermediate Frequency):	35 MHz
IF Bandwidth:	0.8 MHz, nominal
Video Bandwidth:	Commensurate with selected pulse width
STC:	Present in all modes
MDS:	-112 dBm, nominal, on 300 NM range (-901, -902, -911, -912, -921, and -922) -113 dBm, nominal, on 300 NM range (-721 and -722)

Capabilities and Limitations
Table 1-4 (cont)

Avoidance Range	
(Per RTCA DO-173)	
With 12-inch flat-plate antenna:	325 NM
With 10-inch flat-plate antenna:	280 NM
Displayed Ranges	
WX/GMAP:	5, 10, 25, 50, 100, 200, and 300 NM full scale with five concentric range rings (white for WX, green for GMAP)
Flight Plan:	5, 10, 25, 50, 100, 200, 300, 500, and 1000 NM full scale with five concentric range rings (cyan for FP)
Component Weights:	
RTA (7008470-901 and -902)	13.0 pounds, maximum
RTA (7008470-911, -912, -921, -922, -721, and -722)	13.5 pounds, maximum
Indicator	10.0 pounds, maximum
Controller	1.9 pounds, maximum
Panel Illumination:	
Indicator	28 V dc, 0.200 A, nominal, or 5 V ac/dc, 0.750 A, nominal
Controller	28 V dc, 0.3 A, nominal, or 5 V ac/dc, 1.0 A, nominal

Capabilities and Limitations
Table 1-4 (cont)

TSO Compliance	TSO C63c RTCA, Class 7 with Env. Tests per RTCA DO-160B as follows:
	RTA (7008470-901 and -902) F2A/CM/XXX XXXA/AE/AAA 55,000 feet -55 degrees C to +70 degrees C For all fixed wing jet and fixed wing piston and turbo prop less than 12,500 pounds vibration categories.
	RTA (7008470-911, -912, -921, -922, -721 and -722) F2A/JL/XXX XXXA/AE/AAA 55,000 feet -55 degrees C to +70 degrees C For all fixed wing jet and prop vibration categories.
	Indicator B1A/PKS/XXX XXX AAA AA 25,000 feet -20 degrees C to +55 degrees C For all fixed and rotary wing vibration categories.
	Controller B1A/KS/XXX XXX AAA AA 25,000 feet -20 to +55 degrees C For all fixed wing vibration categories.
Primary Power	RTA 28 V dc nominal 110 Watts maximum (22 V dc min to 32 V dc max) 10 V ac, or 26 V ac, or 115 V ac, 400 Hz at 0.12 Watts maximum (Pf = 1.0) NOTE: -90X, -91X units will not operate in the absence of 400 Hz power.

*400 Hz Reference input not used with digital stabilization configuration.

Capabilities and Limitations
Table 1-4 (cont)

Primary Power (cont)	Indicator 28 V dc nominal, 36 Watts maximum (22 V dc min to 32 V dc max)
	Controller 28 V dc nominal, 8.5 Watts maximum (22 V dc min to 32 V dc max)
System Controls	Indicator RANGE ▲ RANGE ▼ SCT scan BRT brightness LSS control (-303 and -304) (OFF-SBY-LX-CLR TST) TILT/Stab Off GAIN Mode control (OFF-SBY-ON-FP-TST) WX GMAP RCT TGT alert AZ
	Controller Range ▲ Range ▼ RCT STAB (Not on -201 through -204) TGT alert SECT scan GAIN/VARIABLE GAIN MODE control (-601 through -604, -622) (OFF-SBY-ON-FP-TEST) RADAR control (-605 through -608 and -201 through -204) (OFF-STBY-WX-GMAP-FP-TST) WX/GMAP (-601 through -604 and -622 only) LSS control (-605, -606, -201 and -202) (OFF-SBY-LX-CLR TST) TILT

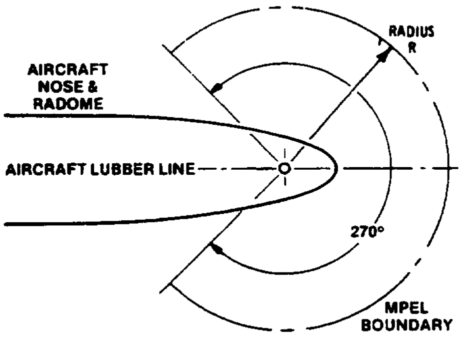
Capabilities and Limitations
Table 1-4 (cont)

G. MAXIMUM PERMISSIBLE EXPOSURE LEVEL

Heating and radiation effects of weather radar can be hazardous to life. Personnel should remain at a distance greater than "R" (see Figure 1-3) from the radiating antenna in order to be outside of the envelope in which radiation exposure levels equal or exceed 10 mW/cm2, the limit recommended in FAA Advisory Circular AC No. 20-68B, August 8, 1980, Subject: "Recommended Radiation Safety Precautions for Ground Operation of Airborne Weather Radar." The radius, R, to the maximum permissible exposure level boundary is calculated for the radar system on the basis of radiator diameter, rated peak-power output, and duty cycle. The greater of the distances calculated for either the far-field or near-field is based on the recommendations outlined in AC No. 20-68B. The advisory circular is reproduced without Appendix 1 in Appendix A of this manual.

The American National Standards Institute, in their document ANSI C95.1-1982, recommends an exposure level of no more than 5 mW/cm^2.

Honeywell Inc. recommends that operators follow the 5 mW/cm^2 standard. Figure 1-3 shows MPEL for both exposure levels.



DIAMETER OF FLAT-PLATE RADIATOR	10 mW/CM^2 RADIUS R OF MPEL BOUNDARY	5 mW/CM^2 RADIUS R OF MPEL BOUNDARY
12 IN 30.5 CM	9 FT 274 CM.	13 FT 396 CM
10 IN. 25.4 CM	8 FT 244 CM	12 FT 366 CM

AD-9659-R1

MPEL Boundary
Figure 1-3

SECTION 2

SYSTEM FUNCTIONAL DESCRIPTION

A. FUNCTIONAL DESCRIPTION

1. RTA (Figure 2-1)

The RTA is an integrated unit which incorporates either a 10-inch or 12-inch flat-plate antenna. Line-of-sight stabilization is employed. The RTA incorporates all circuitry required for transmitting, receiving, signal processing, scan conversion, serial data, and control interface to the other system components as well as the EFIS/MFD.

2. Indicator (Figure 2-2)

The Indicator incorporates a full color digital weather radar display system and weather radar control functions. Both weather display and ground mapping functions are provided. The Indicator features electronic display of range, mode, and status information as well as system fault analysis display and maintenance memory. The Indicator interfaces with the remainder of the system through serial data and control buses, and to auxiliary systems such as DATA NAV or Lightning Sensor System, through a standard UDI for non-weather related navigational data or Lightning Detection. The display system uses a 5-inch, high contrast CRT with a bonded, contrast-enhanced filter. Anti-reflectant coating is employed.

3. Controller (Figure 2-3)

The Controller provides the necessary control functions when the RTA is used with EFIS, MFD, and when the dedicated radar display is not required. Control to the RTA is via a serial control bus. UDI is not provided.

B. FUNCTIONAL OPERATION

The PRIMUS® 650 system can be operated with single or dual Controllers, or a single Indicator.

1. Single Controller Operation

The Controller is connected to the RTA primary control bus. Both directions of antenna sweep are controlled by this Controller.

2. Dual Controller Full Dual Operation

   Two Controllers are used. The left-side Controller is connected to the primary control bus and the right-side Controller is connected to the alternate control bus. In this configuration, the left-side Controller is effective when the antenna is sweeping from right-to-left and the right-side Controller is effective when the antenna is sweeping from left-to-right. This configuration permits independent display of data to each side of the aircraft with independent control for each side. When operating in this configuration, certain positions of the mode selectors will cause the displayed data to be slaved to the opposite side Controller as shown in truth table, Table 2-1. When operating in this configuration, pressing the SECT pushbutton on either Controller will cause the RTA to toggle to 60 degrees scan if it is in 120 degrees scan or vice versa. When both Controllers are on and 60 degrees scan is selected, both displays will be 60 degrees.

3. Single Control Operation With WI-650 Indicator

   No controllers are used. The Indicator contains control circuits and display circuits and is connected to one of the picture bus outputs from the RTA, and to the primary bidirectional control bus input to the RTA.

   Update of the Indicator display takes place on both CW and CCW sweeps of the antenna.

   EFIS displays may be driven from the RTA and will be controlled by the Indicator.

4. Dual Controller Master-Slave With External Transfer Switch

   Two Controllers are used. The control buses of these two Controllers are routed through a remotely mounted transfer switch with the common of the transfer switch connected to the RTA primary control bus. In this configuration, only one Controller is active at any given time, depending on the position of the transfer switch, and both directions of antenna sweep are controlled from the currently active Controller.

Left Controller Mode	Right Controller Mode	Left EHSI (Note 1)	Right EHSI (Note 1)	RTA Mode
OFF	OFF	OFF	OFF	OFF
OFF	Standby	Standby [2]	Standby	Standby
Standby	OFF	Standby	Standby [2]	Standby
OFF	ON	ON [2]	ON	ON
ON	OFF	ON	ON [2]	ON
Standby	ON	Standby [3]	ON/2	ON [3]
ON	Standby	ON [3]	Standby [3]	ON [3]
ON	ON	ON [3]	ON [3]	ON
Standby	Standby	Standby	Standby	Standby

NOTES: 1. Applies only to radar function as displayed on EHSI.

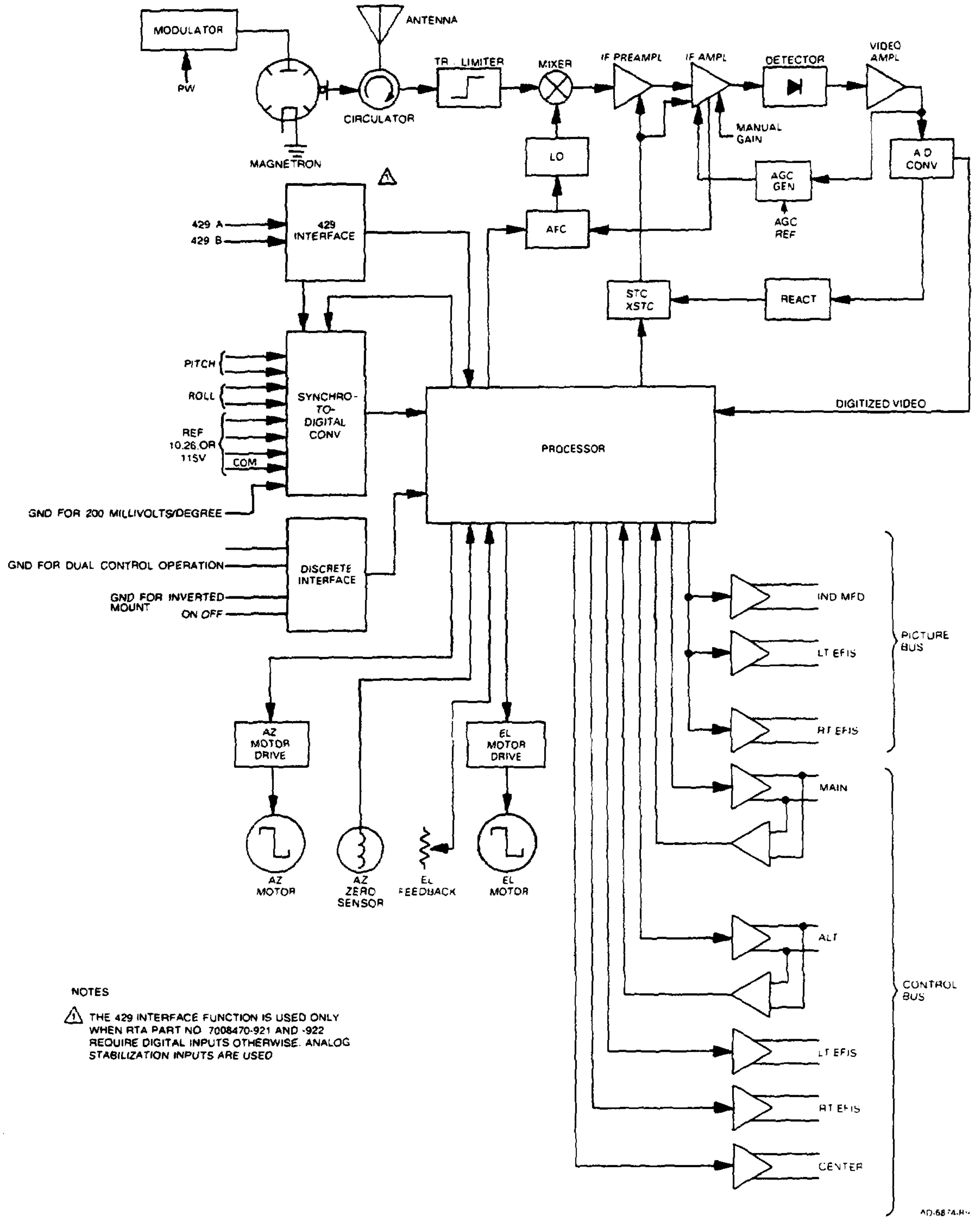
[2] Means that displayed data is controlled by opposite side Controller.

[3] Means that display is controlled by the appropriate control for the antenna sweep direction associated with that control. (/2 implies two Controllers are on.)

4. In Standby, RTA antenna is centered in azimuth with 15 degrees upward tilt. Video data is suppressed. Transmitter is inhibited.

5. Center display, if used, may repeat either left-side data or right-side data, depending upon external switch selection.

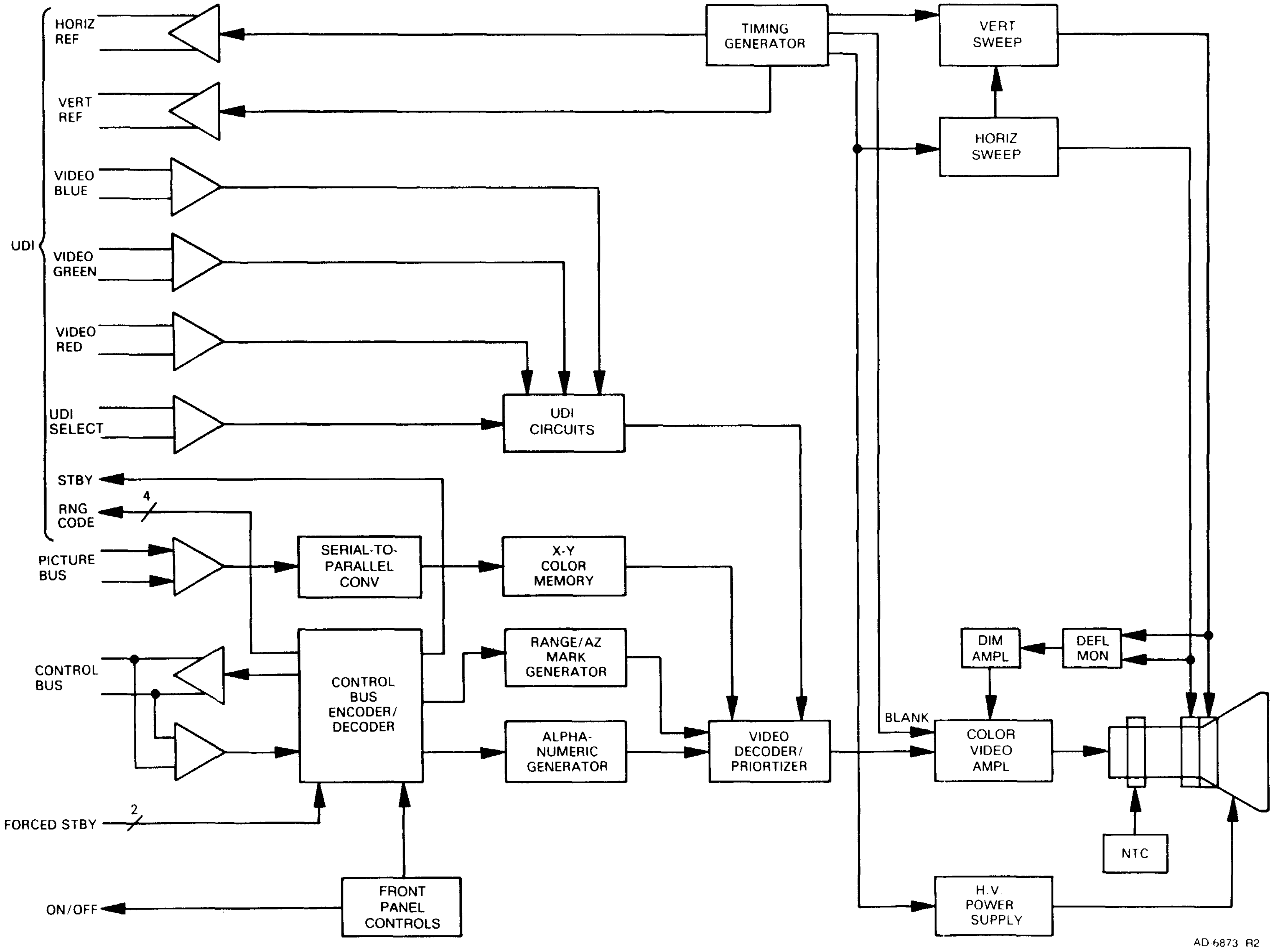
Dual Control Mode Truth Table
Table 2-1



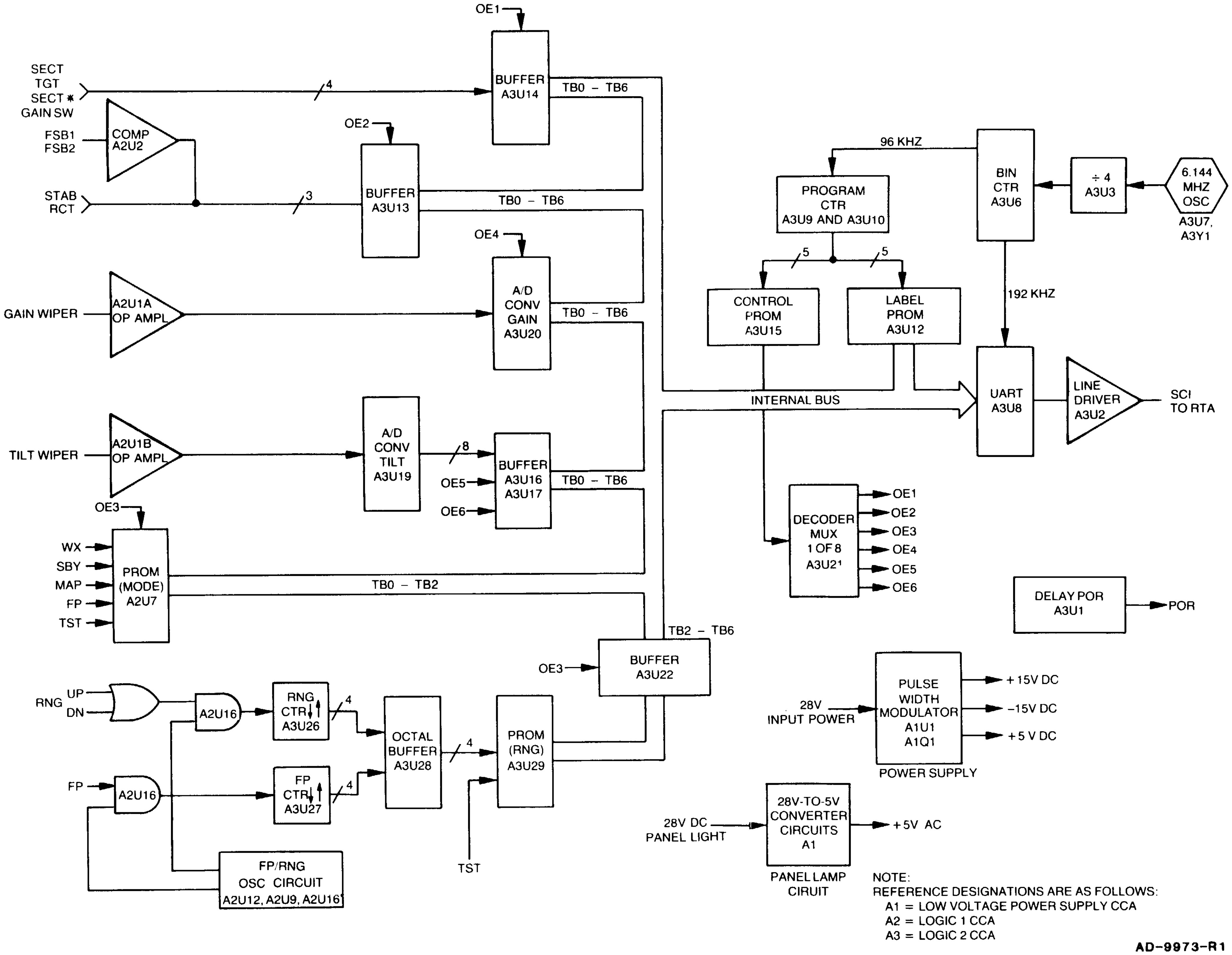
NOTES

⚠1 THE 429 INTERFACE FUNCTION IS USED ONLY WHEN RTA PART NO 7008470-921 AND -922 REQUIRE DIGITAL INPUTS OTHERWISE. ANALOG STABILIZATION INPUTS ARE USED

RTA Block Diagram
Figure 2-1



Indicator Block Diagram
Figure 2-2



Controller Block Diagram
Figure 2-3

SECTION 3

OPERATION

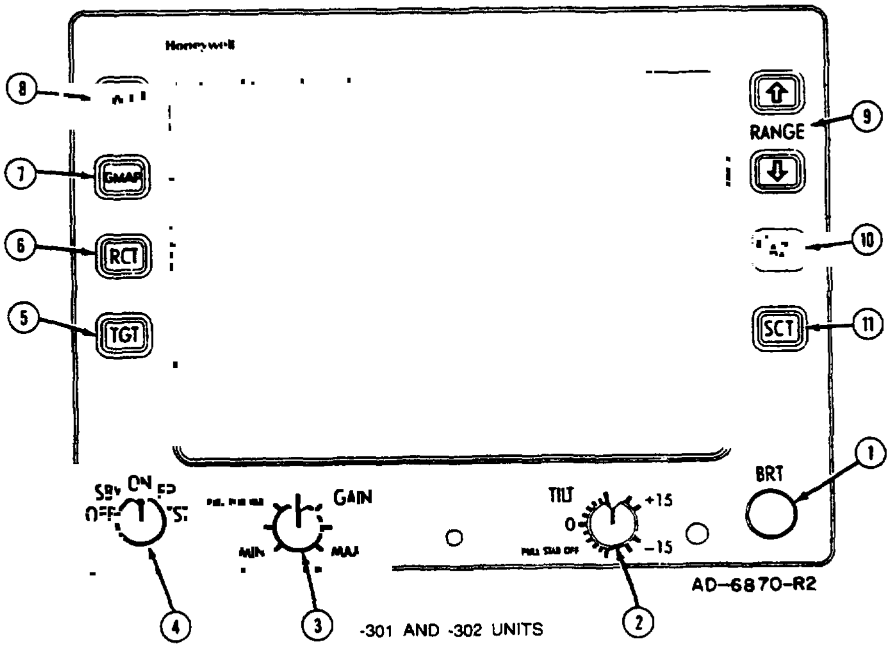
A. GENERAL

The system can be operated in four modes: standby, on (ON), flight plan (FP), or test. In standby the antenna is stowed and the transmitter is disabled. In on, either weather (WX) or ground-mapping (GMAP) information is selectable for display. In flight plan, only navigational data entered via the UDI port is displayed. In test, a test pattern is displayed, and unfiltered video is displayed in the noise band commencing at 80 NM.

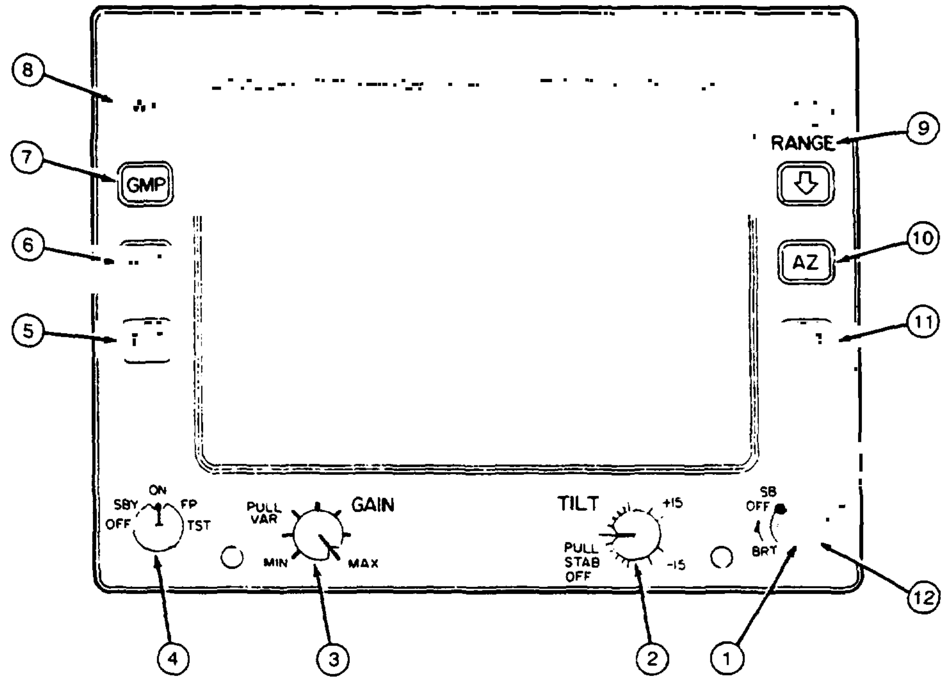
B. CONTROL AND DISPLAY FEATURES

The controls required to operate the system are located on the Indicator or Controller front panel. Front panel views of both the Indicator and the Controller and a descriptive list of control functions are illustrated in Figures 3-1 and 3-2 and described in Tables 3-1 and 3-2.

Figure 3-3 shows the Indicator display screen features.



-301 AND -302 UNITS



-303 AND -304 UNITS

AD-15871-R2

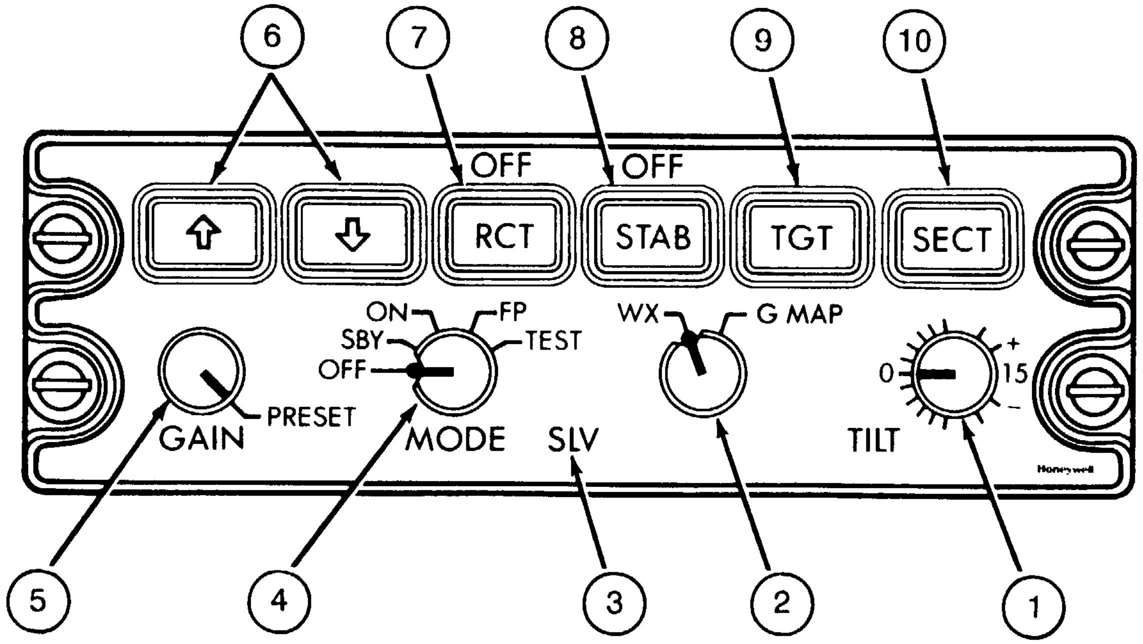
Indicator Front Panel View
Figure 3-1

①	BRT	-	Single-turn display brightness control that adjusts brightness of display. CW rotation increases display brightness and CCW rotation decreases brightness.
②	TILT	-	Single-turn rotary control which varies antenna tilt between 15 degrees up and 15 degrees down. The range between +5 degrees and -5 degrees is expanded for ease of setability. When pulled, stabilization inputs are disabled and pitch and roll are assumed to be zero.
③	GAIN	-	Single-turn rotary control which varies the RTA receiver gain. Control is active when pulled, and when pushed, receiver gain is preset and calibrated. Selection of RCT overrides the variable gain setting causing receiver gain to be fixed and calibrated. Refer to paragraph C.6 of this section for additional details on gain. CW position produces preset gain.
④	Mode	-	Five-position rotary control which selects primary radar modes.
	OFF	-	Removes power from system.
	SBY	-	Standby. Places system in nonoperational mode.
	ON	-	Places system in the operational mode selected by WX or GMAP pushbuttons.
	FP	-	Flight Plan. Permits the singular display of navigational data provided through the UDI port.
	TST	-	Activates the system self-test mode.
⑤	TGT	-	Momentary alternate-action pushbutton which enables the Target Alert function. RTA becomes operational if FP mode is selected and Target Alert enabled.
⑥	RCT	-	Momentary alternate-action pushbutton which enables the function. REACT is selected automatically in TST mode for -201 thru -204.

Indicator Control Functions
Table 3-1

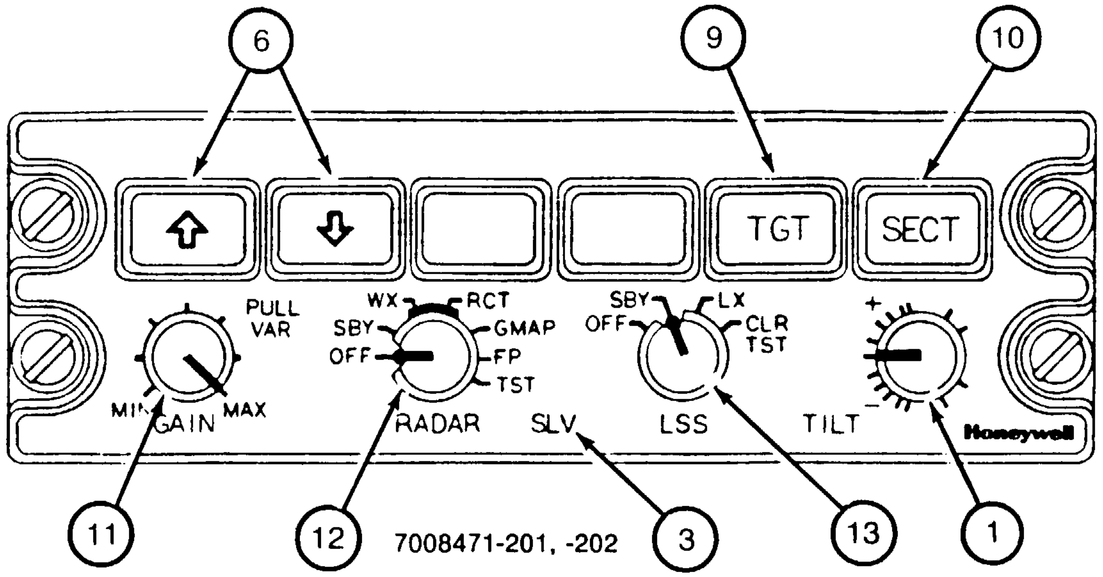
⑦	GMAP (GMP)	-	Momentary pushbutton which selects the ground mapping display mode.
⑧	WX	-	Momentary pushbutton which selects the weather display mode.
⑨	RANGE	-	Two-pushbutton range selection system which permits range selection from 5 to 300 NM full scale in the ON (WX or GMP) or SBY mode, and from 5 to 1000 NM full scale in the Flight Plan mode. In the TST (TEST) mode, the range is automatically set to the 100 NM range, and the range buttons have no control. The "up arrow" pushbutton selects increasing ranges while the "down arrow" pushbutton selects decreasing ranges. The last range is remembered when switching between ON and FP. Upon reaching maximum or minimum range, further pressing of the pushbutton causes the range to rollover to minimum or maximum range, respectively. If FSBY is wired to a weight-on-wheels switch, the unit will be in Forced Standby on the ground unless both RANGE pushbuttons are pressed simultaneously.
⑩	AZ	-	Momentary alternate-action pushbutton which permits displaying and removing azimuth marks from the display.
⑪	SCT	-	Alternate-action pushbutton which selects either full azimuth scan angle (120 degrees) or sector azimuth scan angle (60 degrees).
⑫	LSS	-	(-303 and -304 Units) Four position rotary control which controls the Lightning Sensor System (LSS).
	OFF	-	Removes power from LSS.
	SBY	-	Standby. Places system in nonoperational mode.
	LX	-	Places system in operational mode.
	CLR TST	-	Clear Test. Clears display and then activates the system self-test mode.

Indicator Control Functions
Table 3-1 (cont)

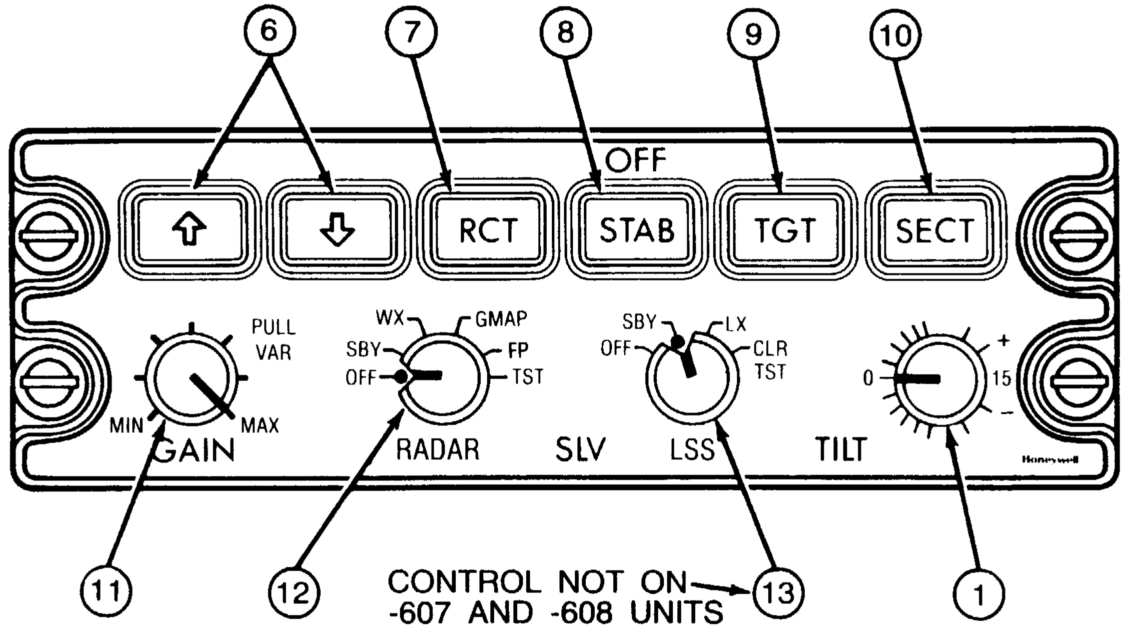


-601 THRU -604 AND -622 UNITS

AD-7766-R4



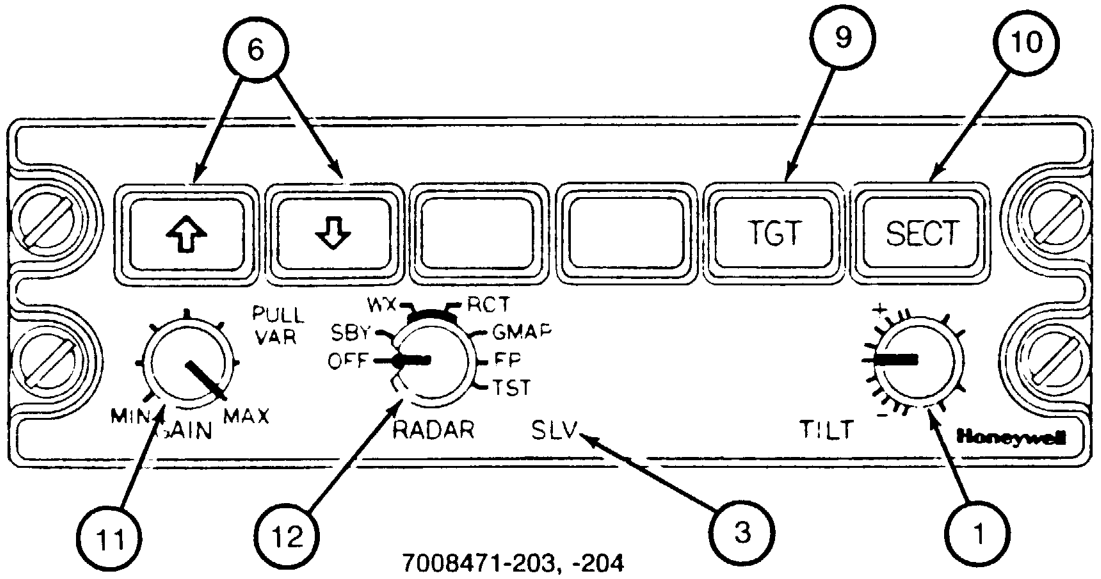
7008471-201, -202



CONTROL NOT ON -607 AND -608 UNITS

-605 THRU -608 UNITS

AD-15872-R2



7008471-203, -204

NOTE: THE -201 THRU -204 CONTROLERS ARE
PRIMUS 870 CONTROLLERS MODIFIED
FOR USE IN A PRIMUS 650 SYSTEM.

AD-16920-R1

Controller Front Panel View
Figure 3-2

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①	TILT	Single-turn rotary control which varies antenna tilt between 15 degrees up and 15 degrees down. The range between +5 degrees and -5 degrees is expanded for ease of setability.
②	WX/GMAP	Two-position rotary switch which selects weather or map display when the MODE switch is in the ON position. (-601 thru -604, -622 only).
③	SLV	Annunciator centered on the lower edge of the panel. This annunciator is used in a dual Controller installation and lights whenever this Controller is in the OFF mode and the opposite side Controller is in any mode except OFF.
④	MODE	Five-position rotary switch which selects primary radar modes. (-601 thru -604, -622 only).
	OFF	Removes power from system.
	STBY	Standby. Places system in nonoperational mode.
	ON	Selects the WX or GMAP display depending on position of the WX/GMAP switch.
	FP	Selects the system flight plan (navigation) display mode.
	TEST	Selects the system self-test mode.
⑤	GAIN	Single-turn rotary control which varies the RTA receiver gain. A detented PRESET position is provided at the full CW end of rotation. Selection of RCT overrides the GAIN control setting and forces preset gain. Refer to paragraph C.6. of this section for additional details. (-601 thru -604, -622 only). - Full CCW rotation commands minimum receiver gain. - Full CW rotation into the detent commands a calibrated preset gain. - Full CW rotation (not into the detent position) commands preset gain.

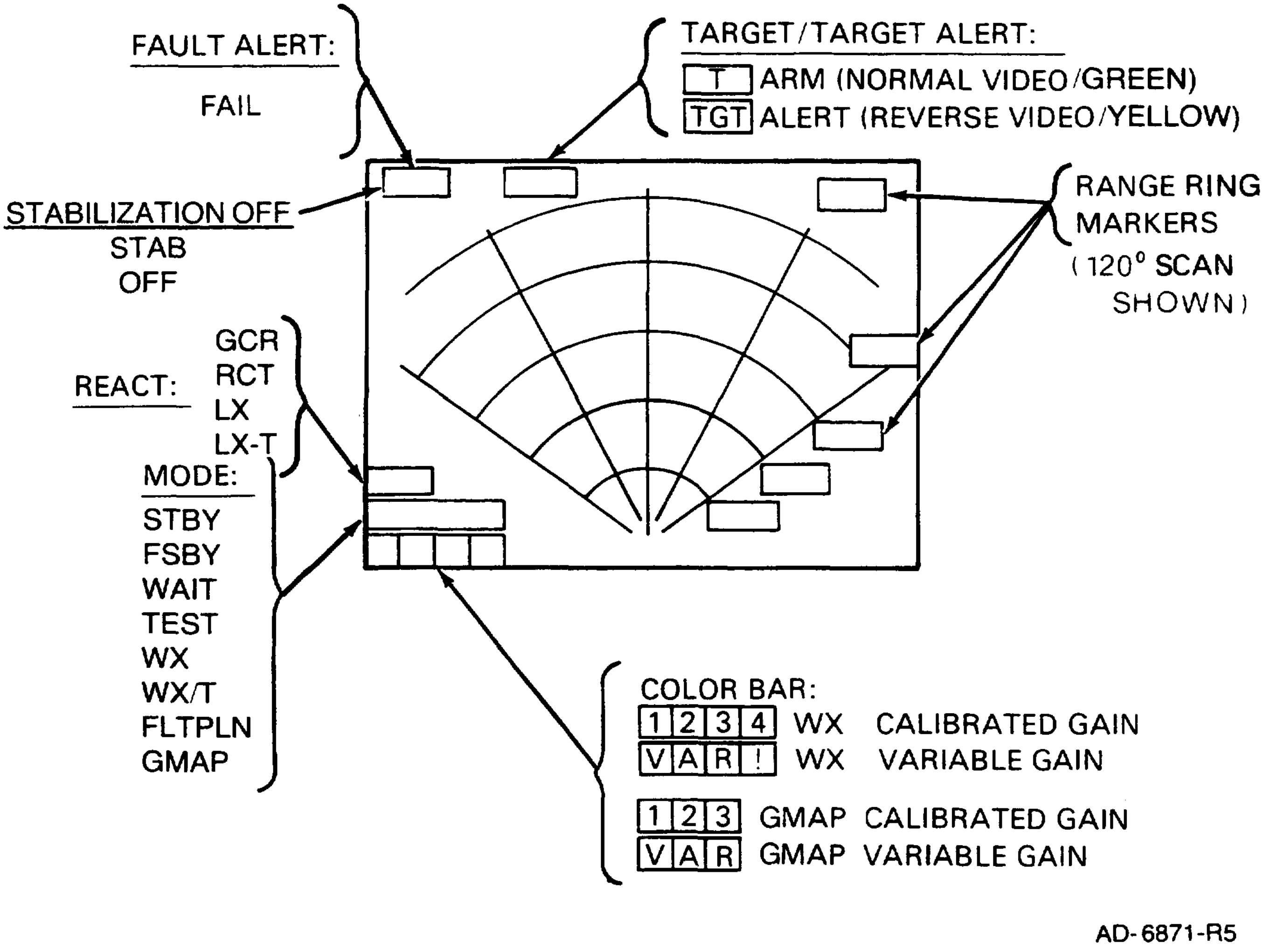
Controller Control Functions
Table 3-2

⑥	Range	-	Two-pushbutton range selection system which permits range selection from 5 to 300 NM full scale in the ON (WX or GMAP) or SBY mode, and from 5 to 1000 NM full scale in the Flight Plan mode. In the TST (TEST) mode, the range is automatically set to the 100 NM range, and the range buttons have no control. The "up arrow" pushbutton selects increasing ranges while the "down arrow" pushbutton selects decreasing ranges. If FSBY is wired to a weight-on-wheels switch, the unit will be in Forced Standby on the ground unless both RANGE pushbuttons are pressed simultaneously.
⑦	RCT	-	Momentary alternate-action pushbutton (or RCT position on RADAR switch on -201 thru -204 only) which enables the function. REACT is selected automatically in the TST mode for -201 thru -204 units only).
⑧	STAB (Not on -201 thru -204)	-	Momentary alternate-action pushbutton which permits disabling stabilization inputs. When disabled, the OFF condition is annunciated above the switch, in which case pitch and roll inputs are assumed to be zero.
⑨	TGT	-	Momentary alternate-action pushbutton which selects target alert function. RTA becomes operational if FP mode is selected and Target Alert enabled.
⑩	SECT	-	Sector. Momentary alternate-action pushbutton which selects either full azimuth scan (120 degrees) or sector azimuth scan (60 degrees).
⑪	GAIN	-	Single-turn rotary control which varies the RTA receiver gain. Control is active when pulled, and when pushed, receiver gain is preset and calibrated. Selection of RCT overrides the variable gain setting causing receiver gain to be fixed and calibrated. (-604 thru -608 and -201 thru -204 only).

Controller Control Functions
Table 3-2 (cont)

⑫	RADAR	-	(-605 through -608 units) Six-position rotary switch which selects primary radar modes.
	OFF	-	Removes power from system.
	SBY	-	Standby. Places system in non-operational mode.
	WX	-	Selects the weather display mode.
	WX/RCT	-	Enables RCT function in WX mode (-201 thru -204 only).
	GMAP	-	Selects the ground map display mode.
	FP	-	Selects the system flight plan (navigation) display mode.
	TST	-	Test. Selects the system self-test mode.
⑬	LSS	-	(-605 and -606 and -201 thru -202 units) Four position rotary control which controls the Lightning Sensor System (LSS).
	OFF	-	Removes power from LSS.
	SBY	-	Standby. Places system in non-operational mode.
	LX	-	Places system in operational mode.
	CLR TST	-	Clear Test. Clears display and then activates the system self-test mode.

Controller Control Functions
Table 3-2 (cont)



Indicator Display Screen Features
Figure 3-3

C. OPERATION

1. Preliminary Control Settings

Place the system controls in the following positions before applying power from the aircraft electrical system:

Mode control	OFF
GAIN control	Preset Position
TILT control	+15

NOTE: Verify that the XMTR ON switch and the SCAN ON switch (see Figure 6-5) both accessible through the base of the RTA are in the ON position (away from the antenna). If not, it will result in an AFC Fault being displayed by the Indicator for XMTR OFF and a SCAN Fail for SCAN OFF.

2. Precautions

If the radar system is to be operated in any mode other than standby while the aircraft is on the ground:

(a) Direct nose of aircraft so that antenna scan sector is free of large metallic objects such as hangars or other aircraft for a distance of 100 feet (30 meters), and tilt antenna fully upwards.

(b) Avoid operation during refueling of aircraft or during refueling operations within 100 feet (30 meters).

(c) Avoid operation if personnel are standing too close to the 270-degree forward sector of aircraft. (Refer to Maximum Permissible Exposure Level paragraph in this manual.)

(d) Operating personnel should be familiar with FAA AC 20-68B, which is reproduced in Appendix A of this manual.

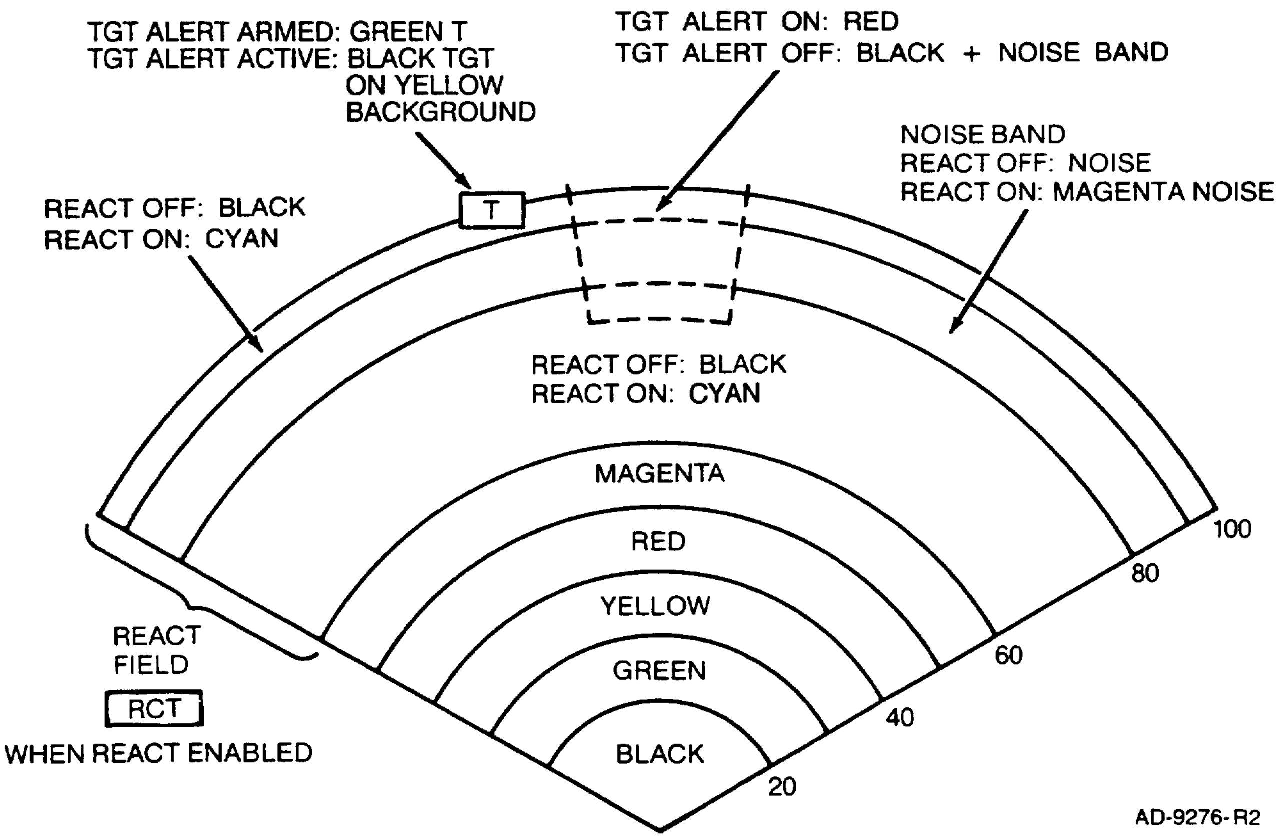
3. Power-Up

If used with an EFIS display, select EFIS to display radar. On power-up, select either Standby or Test Mode. When power is first applied the radar will be in WAIT for 45 seconds to allow the magnetron to warm up. Power sequences ON-OFF-ON lasting less than the initial 45-second wait result in a 6-second wait period.

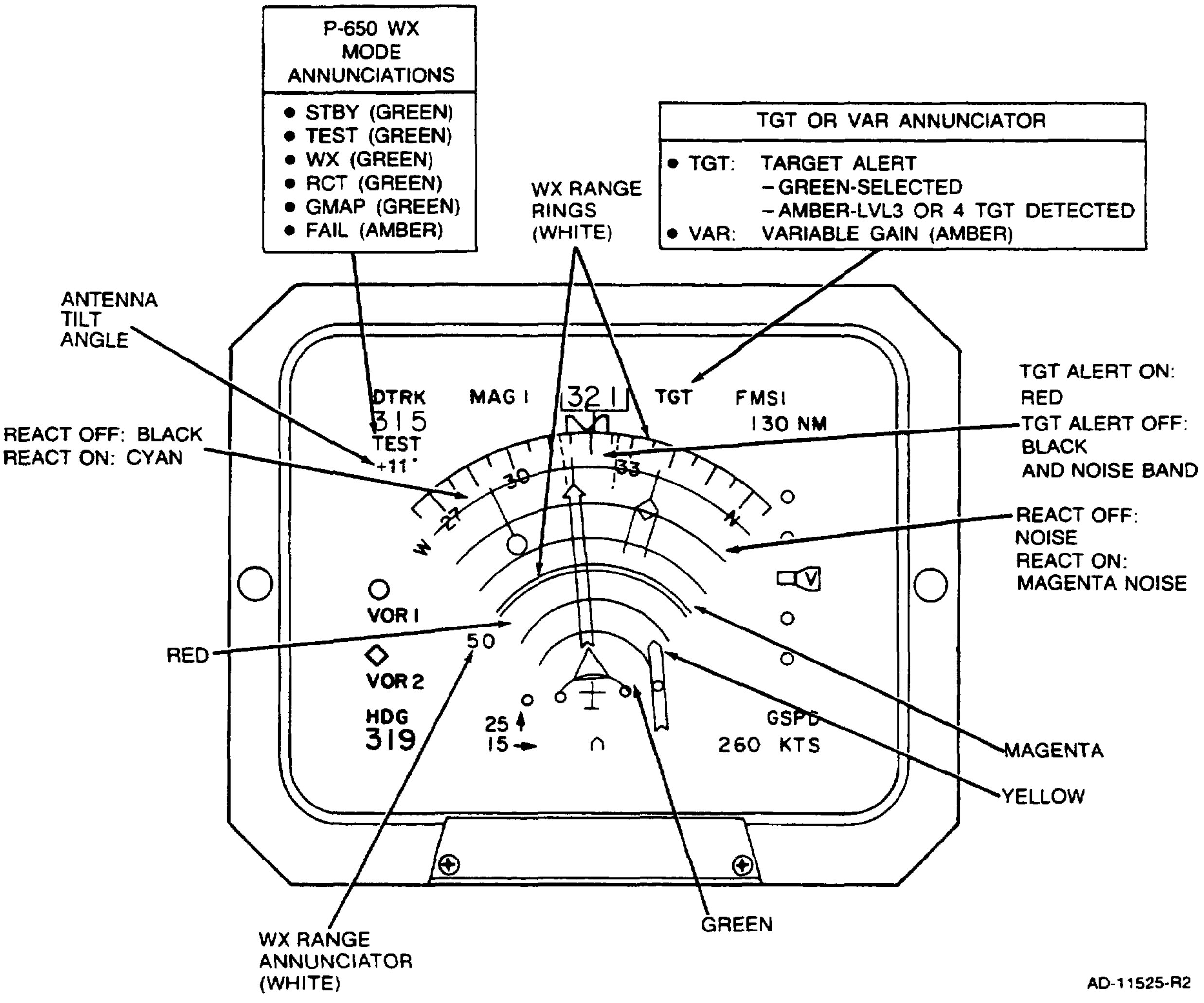
WARNING: OUTPUT POWER IS RADIATED IN TEST MODE.

After the warm-up, select Test mode and verify that the test pattern appears as shown in Figure 3-4. If used with an EFIS, the display will be similar to that shown in Figure 3-5. If the noise band is missing or broken, it is indicative of problems in the system.

Check the function of the Azimuth Marks, Target Alert (TGT), RCT, and sector scan controls.



Indicator Test Pattern
120-Degree Scan Shown
Figure 3-4



EFIS WX Test Pattern (Typical)
120-Degree Scan Shown
Figure 3-5

C. 4. Standby

When Standby is selected, and the radar is not in dual control mode (see Dual Control Mode Truth Table, Table 2-1, for Dual Control Operation) the antenna is stowed in a tilt-up position and is neither scanning nor transmitting.

Standby should be selected any time it is desired to keep power on the system without transmitting.

The PRIMUS® 650 contains a forced standby function (FSBY). This permits an external system, such as the squat switch to force the radar into standby automatically. If this occurs, the mode FSBY will be displayed. If this function is wired, and should it operate, the user may override it by pressing both range buttons simultaneously. In systems with dual controllers, this must be repeated on the second controller.

5. Radar Mode - Weather

For purposes of weather avoidance, pilots are urged to familiarize themselves with FAA Advisory Circular AC 00-24A (6-23-78). Subject: "Thunderstorms." The advisory circular is reproduced in Appendix A of this manual.

To assist the pilot in categorizing storms approximately as described in the above-referenced advisory circular, the radar receiver gain is calibrated in the WX mode with the GAIN Control in the Preset position. The radar is not calibrated when variable gain is being used, but calibration is restored if RCT or Target Alert (TGT) is selected.

In order to permit the user to interpret the display, targets are displayed in various colors. Each color represents a specific target intensity. The intensity levels chosen are related to the National Weather Service VIP (Video Integrated Processor) levels as shown in Table 3-3.

In the WX mode, PRIMUS® 650 displays four levels as black, green, yellow, red, and magenta.

DISPLAY LEVEL	RAINFALL RATE (MM/HR)	RAINFALL RATE (INCHES/HR)	VIDEO INTEGRATED PROCESSOR (VIP) CATEGORIZATIONS			MAXIMUM CALIBRATED RANGE (NM) 12-INCH FLAT-PLATE
			STORM CATEGORY	VIP LEVEL	RAINFALL RATE (MM/HR) (INCHES/HR)	
4 MAGENTA	GREATER THAN 52	GREATER THAN 2.1	EXTREME	6	GREATER THAN 125 (5)	175
			INTENSE	5	50-125 (2-5)	
3 (RED)	GREATER THAN 12	GREATER THAN 0.5	VERY STRONG	4	25-50 (1-2)	
	12-52	0.5-2.1	STRONG	3	12-25 (0.5-1)	175
2 (YELLOW)	4-12	0.17-0.5	MODERATE	2	2.5-12 (0.1-0.5)	175
1 (GREEN)	1-4	0.04-0.17	WEAK	1	0.25-2.5 (0.01-0.1)	175
0 (BLACK)	LESS THAN 1	LESS THAN 0.04				--

Display Levels Related To VIP Levels
Table 3-3

Sensitivity Time Control maintains the receiver gain calibration for a range out to 60 NM depending on the range selected. Extended STC (XSTC) extends this for another 95 NM.

The receiver calibration is readily verified by proper appearance of the test pattern and noise band. However, the radar calibration includes a nominal allowance for radome losses. Excessive losses in the radome seriously affect radar calibration, and the only possible means of verification are signal returns from known targets. It is recommended that the pilot report evidence of weak returns to ensure that radome performance is maintained at a level that does not affect radar calibration.

Target Alert is selectable in any WX or FP range except 300 NM. The Target Alert circuit monitors for red level or greater targets within ±7.5 degrees of dead ahead.

In order to activate Target Alert, the target must have the following depth and range characteristics:

Selected Range(NM)	Target Depth(NM)	Target Range(NM)
5	2.0	5 - 55
10	2.0	10 - 60
25	4	25 - 75
50	4	50 - 100
100	4	100 - 150
200	6	200 - 250
300	Inactive	
FP (Flight Plan)	2.0	1 - 55

It should be noted that while Target Alert is functional at the above ranges, it is improbable that a realistic target would be strong enough to be detected if its range exceeds 5 times the displayed range.

Also, note that the Target Alert is inactive within the displayed range. Selecting Target Alert prevents variable gain from being selected.

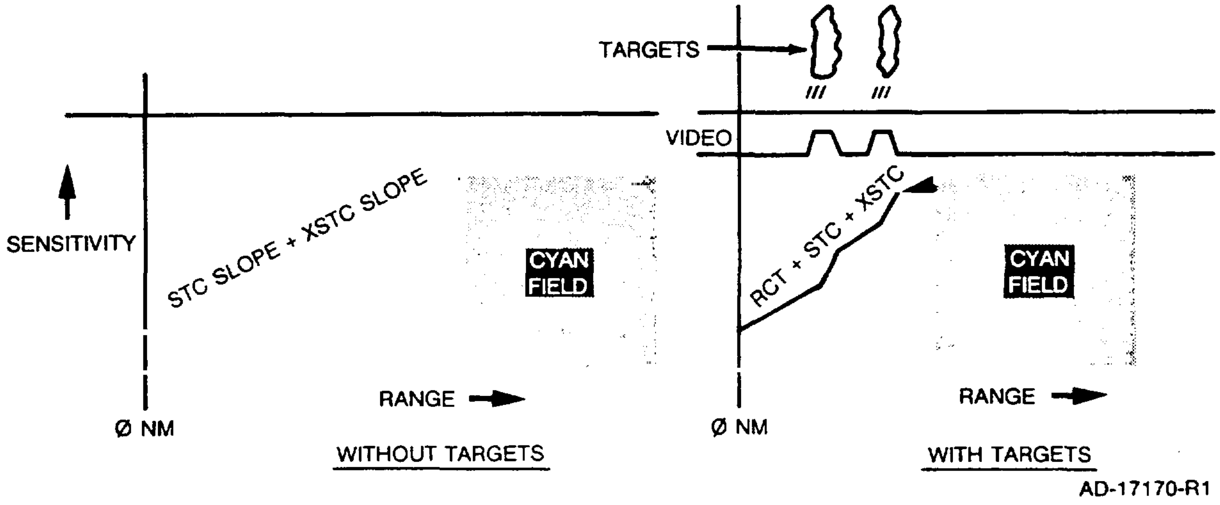
C. 6. Rain Echo Attenuation Compensation Technique (REACT or RCT)

The REACT function permits the radar receiver to adjust its own sensitivity automatically to compensate for attenuation losses as the radar pulse passes through weather targets on its way to illuminate other targets.

This is done by measuring the intensity of signals, and deducing from them the density, and therefore, the attenuation of the target, and then using this information to adjust the sensitivity. This is done continuously on each radar azimuth radial.

There is a maximum value to which sensitivity may be set due to the receiver generating noise, and the display would fill with noise if it were too high. When this maximum value is reached, REACT compensation ceases. At this point, a cyan field is added to the display.

Receiver sensitivity, even in the absence of targets, is gradually increased by the Sensitivity Time Control (STC) and the Extended Sensitivity Time Control (XSTC) circuits with increasing range, to compensate for weakening of targets due to simple distance. The REACT modifies this action. See Figure 3-6.



Gain With/Without Targets
Figure 3-6

In the absence of targets, STC maintains constant system sensitivity until no further receiver gain is available. At this point, the XSTC circuit takes over and maintains constant red sensitivity. When no further XSTC action is possible, it ceases, and system sensitivity starts to decrease.

In the absence of targets in the 200 and 300 NM ranges, STC action will cease at 55 NM and XSTC will end at 155 NM. The cyan field will be displayed beyond 155 NM if REACT is selected. See Figure 3-7.

REACT may be pin-programmed by the installer to operate in one of two optional modes shown below.

Option	Selected by	Description
1	Ground ON P201-R (RTA)	Selecting REACT mode enables Compensation and cyan field.
2	Open ON P201-R (RTA)	Selecting REACT mode enables cyan field only. REACT active at all times in the WX mode.

Option 1 is recommended:

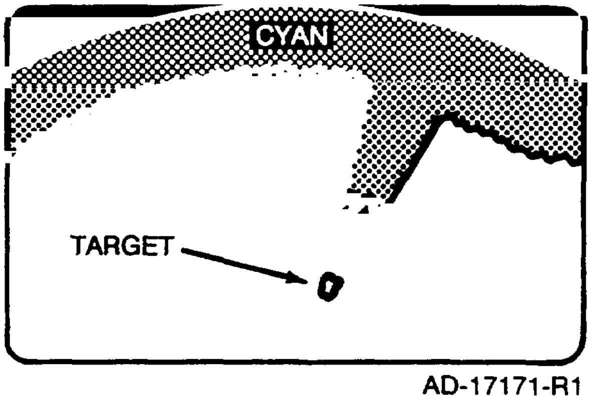
Advantage of Option 1 is:

- Confusing REACT spokes, due to ground targets, are avoided.

Disadvantage of Option 1 is:

- Radar's ability to see the storm behind the storm is reduced, except when REACT is selected.

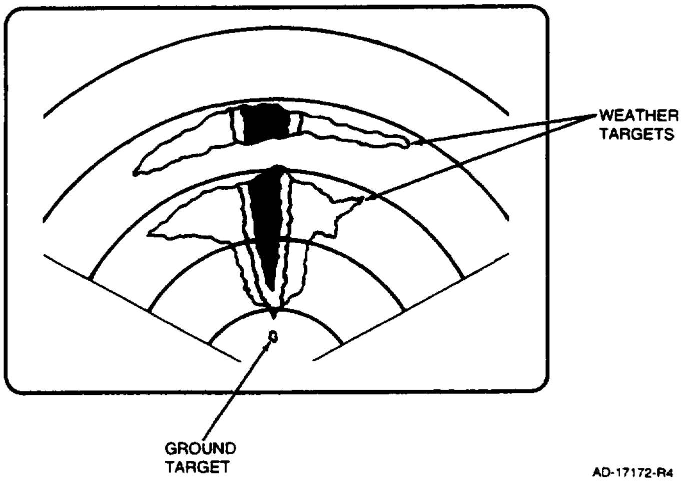
The cyan field annunciates the end of calibrated gain, and will show "fingers" where the sensitivity reaches maximum sooner due to intervening targets. See Figure 3-7.



Display of Finger Due to Ground Targets
Figure 3-7

Any target which occurs in the cyan area is assumed to be very strong, and is displayed in magenta.

If a strong ground target is positioned in front of a weaker target, it may cause an increase in sensitivity in that area, which in turn causes a REACT spoke in the weaker target. See Figure 3-8.



Display at End of Calibration Gain
Figure 3-8

C. 7. Radar Mode - Ground-Mapping

The ground-mapping operation is selected by setting the Mode control to ON and pressing the GMAP pushbutton. The TILT control is turned down until the desired amount of terrain is displayed. The degree of down-tilt will depend upon the aircraft altitude and the selected range.

The receiver STC characteristics are altered to provide equalization of ground-target reflection versus range. As a result, the selection of preset GAIN will generally provide the desired mapping display. However, the pilot may desire to decrease the gain manually by selecting manual gain and rotating the GAIN control.

With experience, the pilot will develop the ability to interpret the color display patterns that indicate water regions, coast lines, hilly or mountainous regions, cities, or even large structures. It is recommended that the pilot practice ground mapping from time to time during flights in clear visibility where the radar display may be compared with the terrain.

C. 8. Hidden Modes

The PRIMUS® 650 has a number of hidden modes which are selected by special control operations. They are not intended for use in normal operations. They are as follows:

Maintenance Page

Entry: Press WX and GMAP simultaneously
Exit: Press WX and GMAP simultaneously
Purpose: Display fault data
Further Information: See paragraph 4.2

Roll Offset Adjustment

Entry: Select WX and VAR GAIN
Select RCT 4 times in 4 seconds
Exit: Select RCT 4 times in 4 seconds
Purpose: Adjust Roll offset to compensate for installation tolerances
Further Information: See paragraph 7.D.5

Stabilization Align Mode

Entry: Scan off/XMTR off/STBY
Exit: Scan on/XMTR on
Purpose: Align Stabilization
Further Information: See paragraph 7.D.3

Forced Standby

Entry: Ground FSB pins on Controller or Indicator
Exit: Remove Ground (above) or press both range buttons simultaneously. (Repeat on second Controller if present).
Purpose: Allow external signal to force radar into SBY
Further Information: See paragraph 3.C.4

SECTION 4

TROUBLESHOOTING

GENERAL

System troubleshooting information is provided in the forms of system malfunctions and suggested corrective action and fault monitors.

1. Malfunctions and Suggested Corrective Action

   A list of malfunctions is presented in Table 4-1, along with suggested corrective action. For detailed troubleshooting procedures for each LRU, refer to the applicable component maintenance manual.

   Before attempting to use these procedures, make certain that the units of the system are properly connected to the aircraft interconnection wiring. Check that the aircraft supply voltages are present and within tolerance.

Malfunction	Corrective Action
Indicator displays WAIT continuously after normal warm-up period (approximately 45 seconds after WX, GMAP, or Test function has been selected)	1. Replace RTA. 2. Replace Indicator. 3. Replace Controller.
Solid colored bands of test pattern are not correct	1. Replace Indicator. 2. Replace RTA.
Test pattern noise band is weak, broken, or missing	1. Check RF cable connection on RTA. 2. Replace RTA.
Range marks displayed incorrectly (number, spacing, or labels)	Replace Indicator.
Azimuth mark lines not displayed	1. Check AZ switch actuation. 2. Replace Indicator.
Target alert not operational; T not displayed in upper portion of Indicator display	1. Check TGT switch actuation. 2. Replace Controller. 3. Replace Indicator.
60 degree scan not selectable	1. Check SCT button actuation. 2. Replace Indicator. 3. Replace Controller.
GAIN control ineffective when operating in WX mode	1. Check MAN GAIN knob actuation. 2. Replace Indicator. 3. Replace Controller. 4. Replace RTA.

System Malfunctions and Suggested Corrective Action
Table 4-1

Malfunction	Corrective Action
Antenna stabilization inoperative	1. Check position of SCAN switch (see Figure 6-5) on RTA. 2. Check gyro. 3. Replace RTA.
Weak or no targets displayed	1. Verify that raster dimmer on EFIS Controller is adjusted properly. 2. Check aircraft wiring (if first time installation). 3. Check that RF connector to IF preamplifier is plugged in on RTA. 4. Replace RTA. 5. Replace Indicator.
No Tilt control	1. Check tilt knob actuation. 2. Replace RTA. 3. Replace Indicator. 4. Replace Controller.
WX Fail	1. Check position of SCAN switch. 2. Check position of XMIT switch. 3. Check wiring. 4. Replace RTA.

System Malfunctions and Suggested Corrective Action
Table 4-1 (cont)

2. Fault Monitors

Critical functions in the RTA and Indicator are continuously monitored. The RTA utilizes the Indicator as the display mechanism by transmitting detected faults to it via the control bus. Details of the faults are provided on a "hidden" display page and may be viewed by simultaneously pressing the WX and GMAP pushbuttons. Both RTA and Indicator faults will be displayed. All faults are stored in a nonvolatile memory, except for INDPS (Indicator Power Supply) and RTA SCI DATA, to enhance postflight maintenance. Exit from the "hidden" display page is accomplished by pressing WX and GMAP pushbuttons simultaneously.

Since the service technician cannot be present when certain momentary failures occur, a history of the faults which have occurred is provided. This history is partitioned into eight "pages" of data, as follows:

Maintenance Page	Contents	Stimulus
0	Current faults	TEST
1	Fault storage from previous power-on cycle.	5 NM (ON)
2	Fault storage from power-on cycle prior to page 1.	10 NM (ON)
3	Fault storage from power-on cycle prior to page 2.	25 NM (ON)
4	Fault storage from power-on cycle prior to page 3.	50 NM (ON)
5	Faults from power-on cycle prior to page 4.	100 NM (ON)
6	Faults from power-on cycle prior to page 5.	200 NM (ON)
7	Faults from power-on on cycle prior to page 6.	300 NM (ON)

In order to view a particular page of data, press WX and GMAP pushbuttons simultaneously, then select the function shown in the Stimulus column for that page.

If the word FAIL appears at the top left of the display, in ON mode, this indicates that a failure message is being presented on maintenance page 0.

When more than one fault message is displayed on a maintenance page, the fault messages are displayed one at a time, for one second each, in the sequence in which they occurred.

If a particular fault occurs more than once in a power-on cycle, it is written only once in the maintenance page.

The fault display format is displayed on the radar indicator and on EFIS is as tabulated below.

Radar Indicator Annunciation	EFIS Fault Code	Fault Description
Monitors OK	None	No fault detected
SCAN	01	Antenna not scanning or scanning incorrectly.
STAB	02	Antenna stabilization errors.
RCVR	03	Radar receiver fault.
MIX	04	Radar signal mixer current out of specification -- probably due to defective mixer diodes.
AFC	05	Radar automatic frequency control fault. Can be caused by a defective transmitter. This fault can be observed in TEST by the display of a broken noise band.
FAN	06	Indicates abnormal fan current for extended period of time.
PROC	07	CPU (microprocessor) fault in RTA.

NOTE: Some PRIMUS 650 installations may display some other number in the leading zero position of the EFIS Fault Code. This should be ignored if seen.

If an EFIS is being used as a display device, the fault code number above will be displayed and should be decoded by reference to the table above.

In the event that there is more than one fault present, the EFIS will display the various codes sequentially.

2. (a) Memory Reset

NOTE: When switching the SCAN and XMTR switches on the RTA housing to the OFF position, the RTA processor recognizes a SCAN and transmitter failure and sets the SCAN and AFC fault BITS. When entering the hidden maintenance pages a history of the faults which have occurred is provided. The fault memory may be cleared by grounding main connector J201 pin E prior to power-up, or an alternate method is to turn the system on/off seven times to clear the maintenance pages.

The RTA fault memory may be cleared by grounding main connector A1J1 pin E during power-up.

(b) External Annunciator Signal

The Indicator provides an external fault annunciator signal in the form of an open drain output on P101/J. This output is low if any Indicator faults are present. Maximum current sink capability is 60 milliamperes and a maximum of 60 V.

When the RTA is used with one or two Controllers, the EHSI will typically display amber WX in the top corner if no SCI data is present. This may be due to an actual bus failure or if the RTA is not powered up. When the RTA serial bus is functioning normally, the EHSI will indicate the presence of any failures detected by the RTA fault monitoring system when in Test mode only, by displaying an amber FAIL in the top corner of the display where TEST is normally displayed.

SECTION 5

SERVICING

A. GENERAL

The radar system requires no servicing in the aircraft beyond those procedures recommended under Check and Cleaning/Painting.

B. LUBRICATION AND SERVICING

Instructions for applying lubricants, sealing, and staking compounds to the appropriate parts and assemblies of the system components are supplied in the appropriate component maintenance manual for each of the line-replaceable units.

SECTION 6

INSTALLATION

A. GENERAL

This section describes the installation of the PRIMUS® 650 COLORADAR system. Outline and installation drawings are shown in Figures 6-1, 6-2, and 6-3. Interconnecting wiring diagrams are shown in Figure 6-4.

B. LOCATION OF EQUIPMENT

The locations chosen for each component of the PRIMUS® 650 COLORADAR system will vary for each installation. The RTA must be mounted in the nose of the aircraft and may be mounted normally with the fan side down or inverted with the fan side up and RTA connector pin S grounded to indicate inverted mount.

C. PRIMARY POWER REQUIREMENTS

The PRIMUS® 650 COLORADAR system operates primarily from the aircraft 28 V dc power system. In addition to the dc power requirement, systems that contain RTA, Part No. 7008470-901, -902, -911, and -912 require roll and pitch signal voltages from the aircraft vertical reference for operation of the antenna stabilization system. The associated 400 Hz, ac reference can be 10 V rms, 26 V rms, or 115 V rms. See the interconnecting wiring diagram in Figure 6-4 for pinouts. This reference signal must be derived from the same source as the vertical reference system. Systems that contain RTA, Part No. 7008470-921, -922, -721 and -722, can either use inputs from the aircraft vertical reference as described above or be wired for ARINC 429 serial bus stabilization inputs, but not both.

D. ROLL AND PITCH INFORMATION

In systems that contain RTA, Part No. 7008470-901, -902, -911, and -912, the stabilization system requires 2-wire pitch and roll signals of 50 millivolts per degree. If 200 millivolts per degree sensitivity is required, RTA connector pin P must be grounded. The phasing must be such that aircraft nose down and roll left give signals at the RTA plug that are in phase with the reference voltage.

NOTE: These voltages are defined by ARINC as E/2300 ±2% (50 millivolts/degree) and E/575 ±2% (200 millivolts/degree) where E is the actual voltage of the 115 V, 400 Hz supply.

E. INSTALLATION OF RTA

The RTA is designed for mounting to the forward bulkhead, in the nose section of the aircraft, behind a radome fabricated to the operating frequency of the radar system. The total space required for the RTA can be determined from the dimensional information contained on the RTA outline and installation drawing, Figure 6-1.

CAUTION: ASCERTAIN THAT THE ANTENNA IS FREE TO MOVE IN AZIMUTH PRIOR TO APPLYING POWER.

The RTA base hole pattern is illustrated in Figure 6-1. The mounting surface provided in the aircraft should be vertical ±1/2 degree in pitch and roll with reference to the vertical reference system mounting plane.

1. Grounding Straps

Grounding straps are required, and are provided as part of the RTA.

2. Shockmounting and Ventilation

Shockmounting is not required. The RTA is designed to operate in the unpressurized nose section of the aircraft. External ventilation is not required.

3. Orientation

The mounting position of the RTA must satisfy the following conditions:

(a) The antenna mounting surface must be vertical within ±1/4 degree to the mounting surface of the vertical reference system pitch and roll.

(b) The antenna mounting plane must be aligned to within ±1 degree of the aircraft's yaw reference axis and to the aircraft's longitudinal axis within ±1 degree.

E. 4. Radome

To allow the most satisfactory radar beam radiation, the nose section in front of the antenna (radome) must be fabricated for X-band (9345 MHz, 3.2 cm) signals. A radome having less than 90 percent one-way transmissivity, at all incidence angles defined by the scan and tilt coverage, will result in degradation of system performance and should not be used. A good radome will have a transmissivity of 90 to 95 percent. An advisory circular on maintenance of radomes is reproduced in Appendix A of this manual.

The radome installed should allow the widest possible angle of useful beam radiation (140 degrees, 70 degrees to each side of aircraft heading).

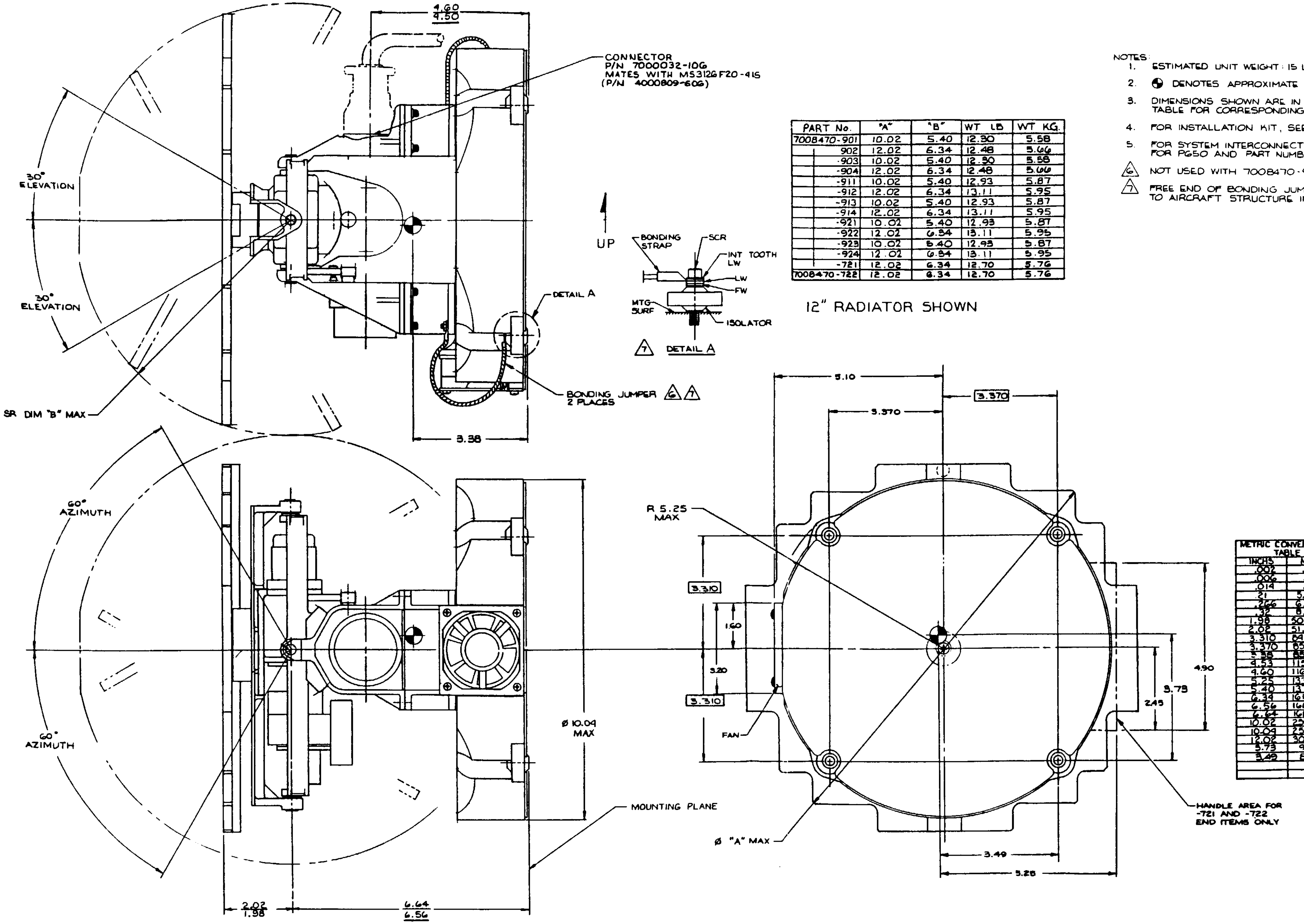
F. INSTALLATION OF INDICATOR

NOTE: To install the Indicator, a 7/64 Allen wrench is required.

The information necessary to install the Indicator is given in the outline and installation drawing, Figure 6-2.

G. INSTALLATION OF CONTROLLER

The information necessary to install the Controller is given in the outline and installation drawing, Figure 6-3.



PART No.	"A"	"B"	WT LB	WT KG.
7008470-901	10.02	5.40	12.30	5.58
902	12.02	6.34	12.48	5.66
-903	10.02	5.40	12.30	5.58
-904	12.02	6.34	12.48	5.66
-911	10.02	5.40	12.93	5.87
-912	12.02	6.34	13.11	5.95
-913	10.02	5.40	12.93	5.87
-914	12.02	6.34	13.11	5.95
-921	10.02	5.40	12.93	5.87
-922	12.02	6.34	13.11	5.95
-923	10.02	5.40	12.93	5.87
-924	12.02	6.34	13.11	5.95
-721	12.02	6.34	12.70	5.76
7008470-722	12.02	6.34	12.70	5.76

12" RADIATOR SHOWN

NOTES:
1. ESTIMATED UNIT WEIGHT: 15 LBS
2. ◕ DENOTES APPROXIMATE CENTER OF GRAVITY.
3. DIMENSIONS SHOWN ARE IN INCHES. SEE METRIC CONVERSION TABLE FOR CORRESPONDING DIMENSION IN MILLIMETERS.
4. FOR INSTALLATION KIT, SEE PART NUMBER 7011070.
5. FOR SYSTEM INTERCONNECT, SEE PART NUMBER 7011082 FOR P650 AND PART NUMBER 7011249 FOR P450.
△6 NOT USED WITH 7008470-901 THRU -904.
△7 FREE END OF BONDING JUMPERS MUST BE SECURELY GROUNDED TO AIRCRAFT STRUCTURE IN ACCORDANCE WITH DETAIL-A.

METRIC CONVERSION TABLE

INCHS	MM
.002	.051
.006	.152
.014	.356
.21	5.33
.266	6.756
.32	8.13
1.98	50.29
2.02	51.31
3.310	84.074
3.370	85.598
3.38	85.85
4.53	115.06
4.60	116.84
5.25	133.35
5.40	137.16
6.34	161.04
6.56	166.62
6.64	168.66
10.02	254.51
10.09	255.02
12.02	305.31
3.73	94.74
3.49	88.65

E7008663-1-N

RTA Outline and Installation Drawing
Figure 6-1

METRIC CONVERSION TABLE	
INCHES	MILLIMETERS
.030	.76
.050	1.27
.070	1.78
.100	2.54
.120	3.05
.185	3.43
.151	3.84
.161	4.09
.250	6.35
.285	7.24
.295	7.49
.495	12.57
.505	12.83
.552	14.02
.572	14.53
.620	15.75
.630	16.00
.710	18.03
.720	18.29
.725	18.42
.735	18.67
.740	18.80
.760	19.30
.802	20.37
.822	20.88
1.660	42.16
1.810	45.97
1.820	46.23
2.135	54.23

METRIC CONVERSION TABLE	
INCHES	MILLIMETERS
2.145	54.48
2.50	63.5
2.905	73.79
2.915	74.04
3.16	80.3
4.710	119.63
4.730	120.14
4.740	120.40
4.760	120.90
4.800	121.92
4.830	122.68
4.995	126.87
5.005	127.13
5.115	129.92
5.135	130.43
5.25	133.4
6.070	154.18
6.090	154.69
6.140	155.96
6.160	156.46
6.235	158.37
6.265	159.13
6.270	159.26
8.495	215.77
8.505	216.03
10.900	276.86
10.990	279.15
11.400	289.56
11.740	298.20

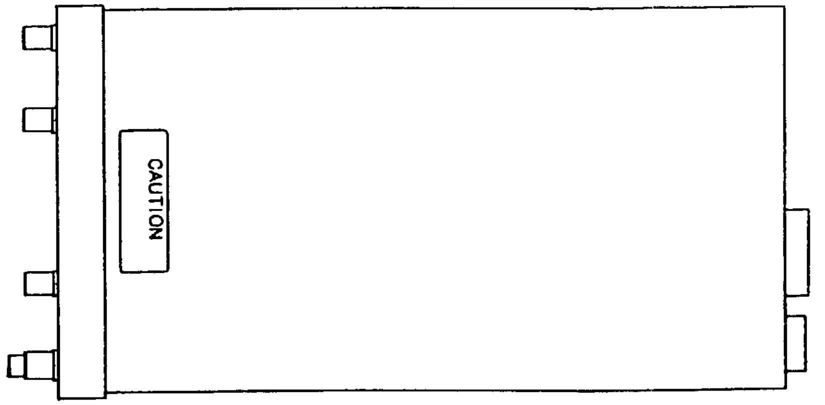
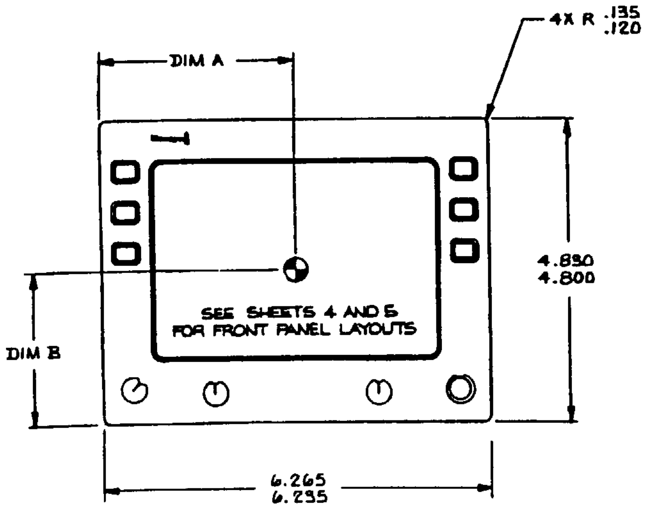
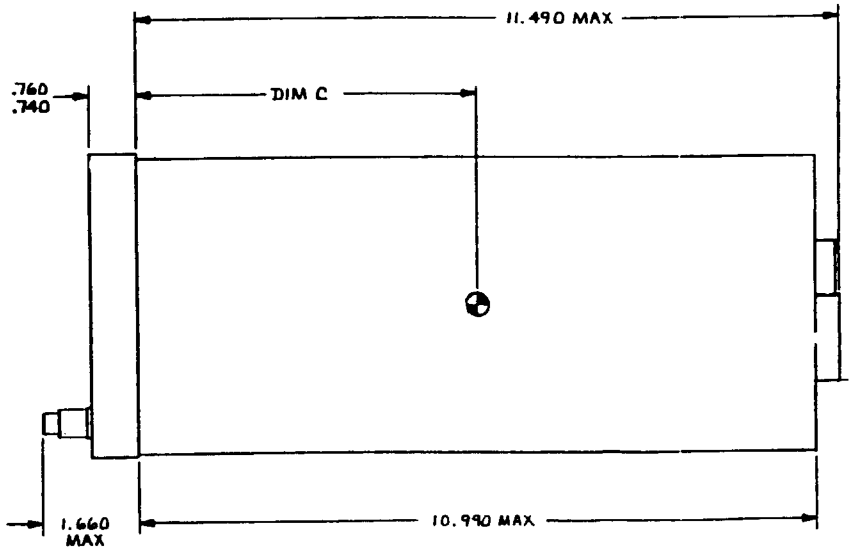


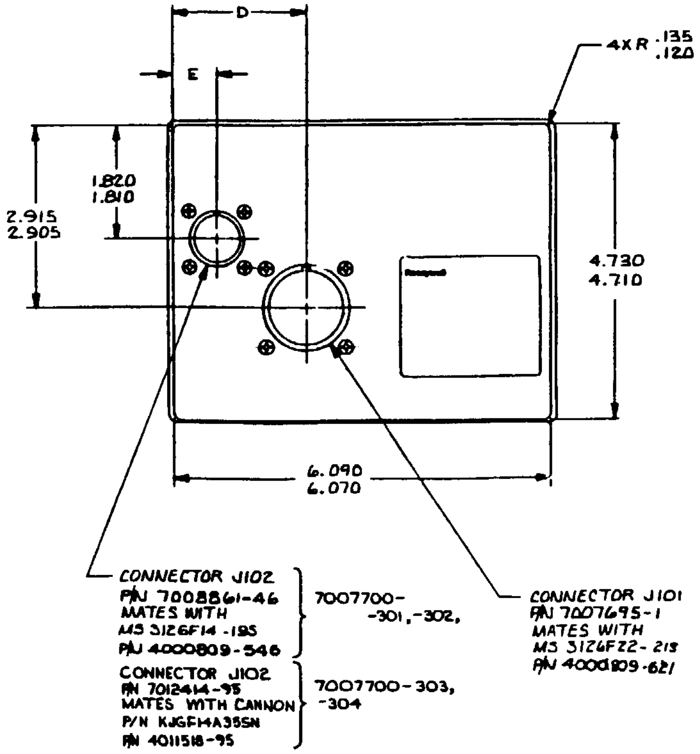
TABLE OF VARIABLES

MODEL NO.	PART NO.	INTEGRATED TEST SPEC	MARKINGS UNLESS OTHERWISE SPECIFIED	AREA LIGHTING		MAX WT LBS [KG]	CENTER OF GRAVITY			DIM D	DIM E	COLOR
				VOLTAGE	COLOR		DIM A	DIM B	DIM C			
WI-450	7007700-301 -302	IT7007700	WHITE	5V/28V	BLU-WHT	12.0 [5.45]	3.16	2.50	5.25	2.145 2.135	.720 .710	GRAY BLACK
WI-700	-303 7007700-304	IT7007700	WHITE	5V/28V	BLU-WHT	12.0 [5.45]	3.16	2.50	5.25	2.145 2.135	.720 .710	GRAY BLACK



SEE SHEET 2 FOR AIRCRAFT PANEL CUTOUT.





NOTES:

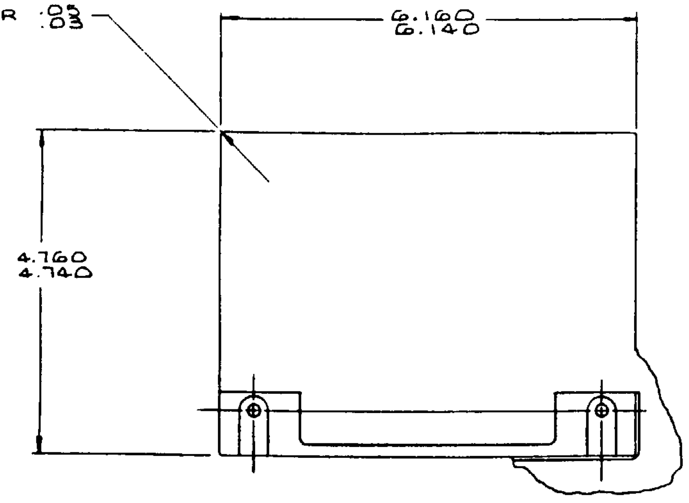
1. ⊕ DENOTES APPROXIMATE CENTER OF GRAVITY.
2. FOR UNIT WEIGHT REFER TO TABLE OF VARIABLES.
3. THIS DRAWING APPLIES TO ALL VARIABLES OF GENERIC RADAR INDICATOR 7007700.
4. DIMENSIONS SHOWN ARE IN INCHES. REFER TO METRIC CONVERSION TABLE FOR CORRESPONDING DIMENSIONS IN MILLIMETERS.

E7008796-1, 2, 3-N

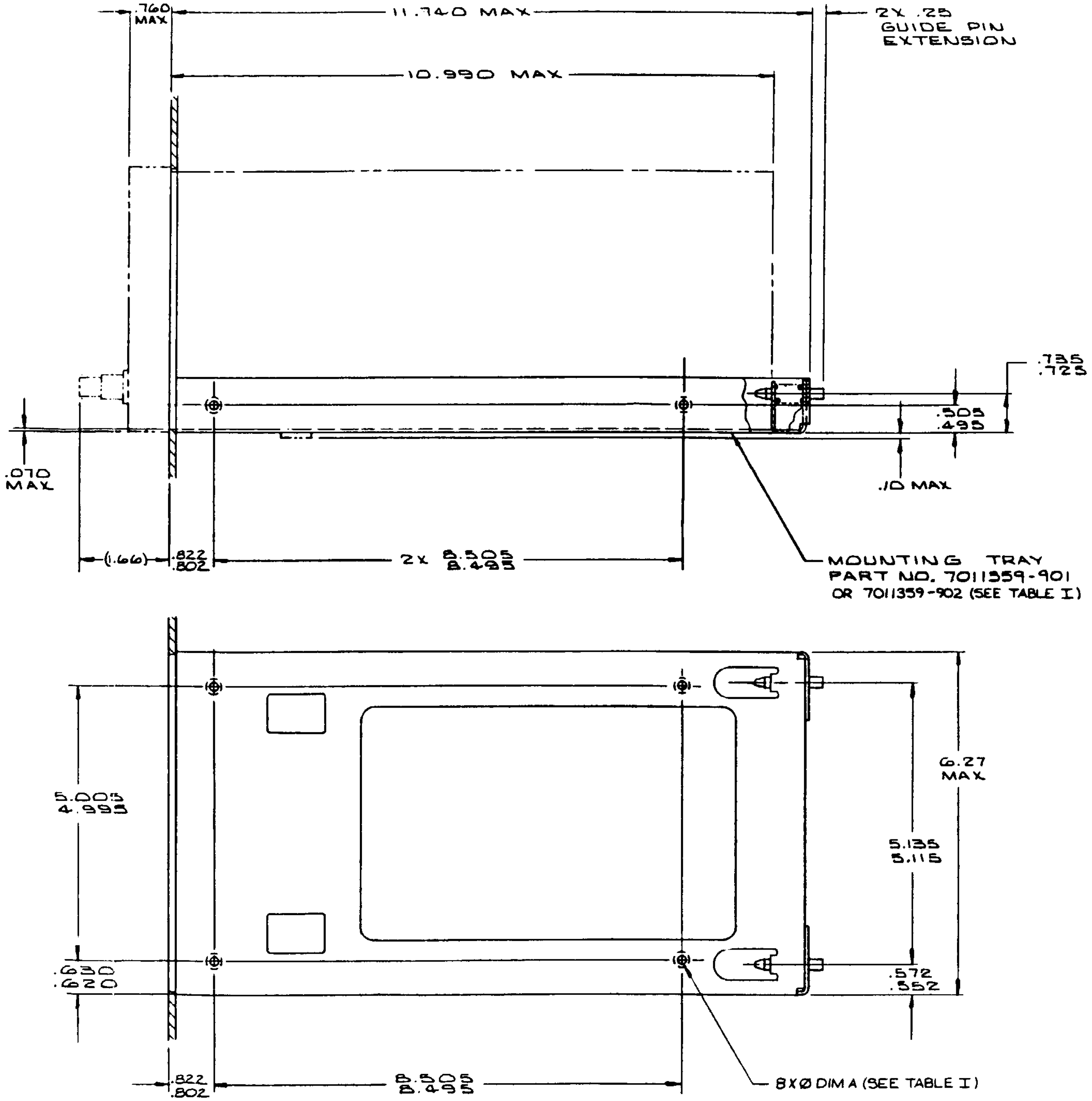
Indicator Outline and Installation Drawing
Figure 6-2 (Sheet 1)

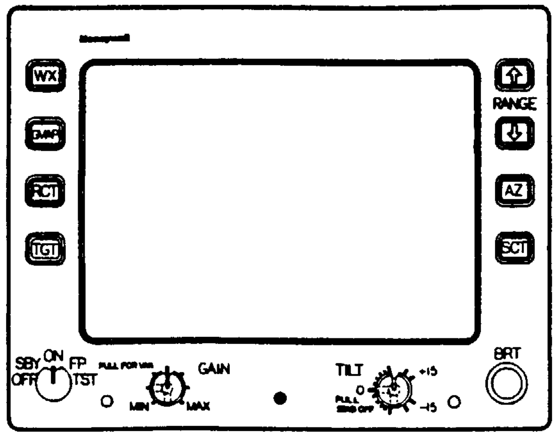
TABLE I

TRAY DASH NO.	HOLE DIM A	MOUNTING HARDWARE	DESCRIPTION
-901	Ø .161 .151 THRU ⌵Ø .295 .285 X 102° 98°	HONEYWELL • 0600-331 / MS20426AD5-6-8 OR EQUIVALENT	.156 X .406 FLUSH RIVET
-902	Ø .152 .142 THRU ⌵Ø .288 .278 X 102° 98°	HONEYWELL • 092-25 / MS51959-25 OR EQUIVALENT	.138 X 32 UNC X .18 FLAT HEAD SCREW

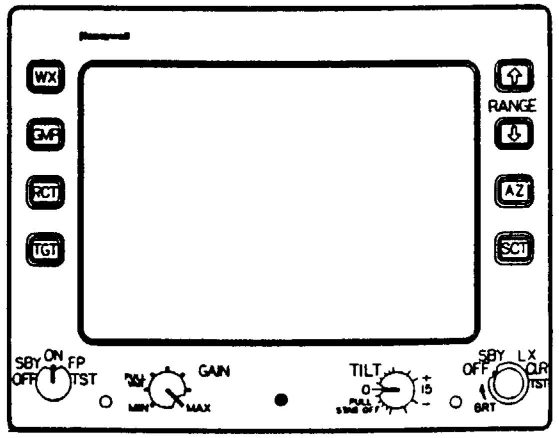


AIRCRAFT PANEL CUTOUT





7007700-301, -302



7007700-303, -304

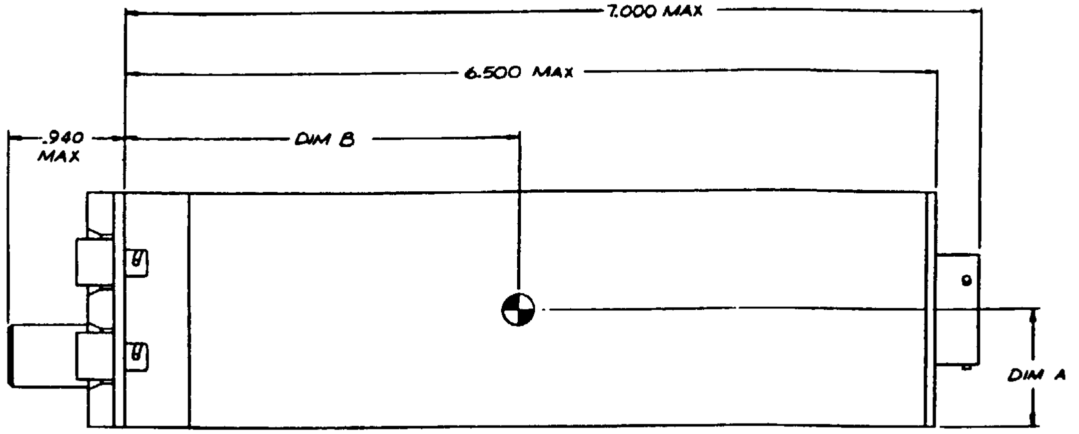
E7007701-2, 4, 5-N

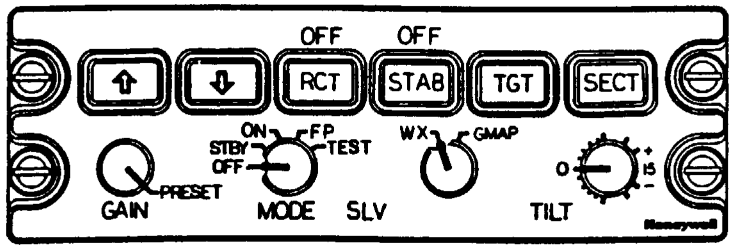
Indicator Outline and Installation Drawing
Figure 6-2 (Sheet 2)

METRIC CONVERSION TABLE	
INCHES	MILLIMETERS
.192	4.53
.375	9.53
.562	14.27
.745	18.92
.755	19.18
.933	23.70
.940	23.83
1.575	47.63
3.100	78.74
5.360	136.14
5.370	136.40
5.750	146.05
6.500	165.10
7.000	177.80

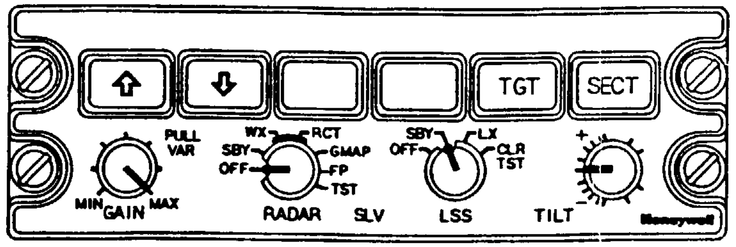
NOTES:

1. ⊕ DENOTES APPROXIMATE CENTER OF GRAVITY.
2. FOR UNIT WEIGHT REFER TO TABLE OF VARIABLES.
3. THIS DRAWING APPLIES TO ALL VARIABLES OF WEATHER RADAR CONTROLLER 7008471.
4. DIMENSIONS SHOWN ARE IN INCHES. REFER TO METRIC CONVERSION TABLE FOR CORRESPONDING DIMENSIONS IN MILLIMETERS.
5. RECOMMENDED MOUNTING PER MS25213.
6. DZUS FASTENER LOCATION DIMENSIONS SHOWN ARE IN ACCORDANCE WITH MS 25212. MAXIMUM ALLOWABLE HEIGHT AND WIDTH DIMENSIONS CAN EXCEED MS 25212 GUIDELINES BY .015 INCHES (.381 MM) TO ACCOMODATE FINISH, DZUS FASTENER DIAMETER, ASSEMBLY AND INSTALLATION TOLERANCES.

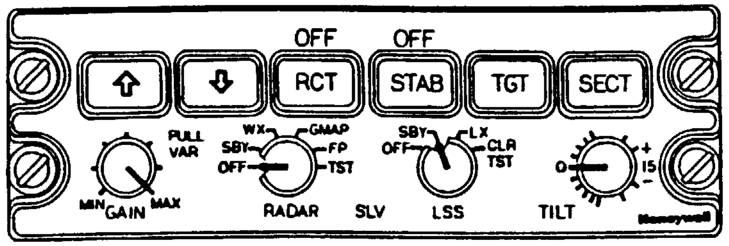




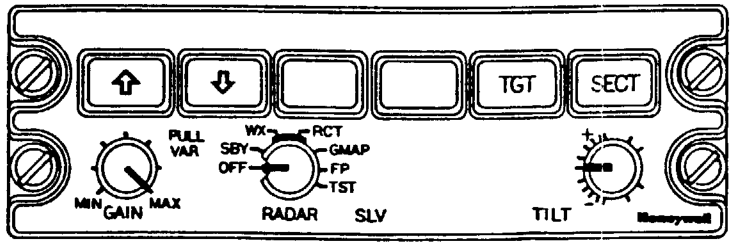
7008471-601 TO -604 AND -622



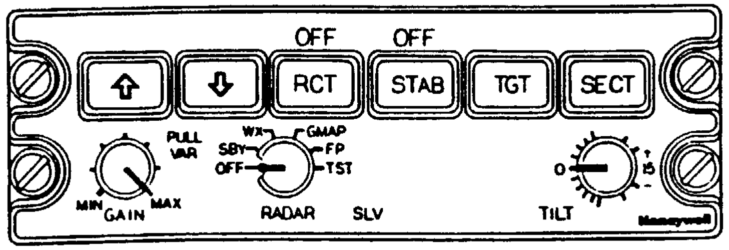
7008471-201,-202



7008471-605,-606



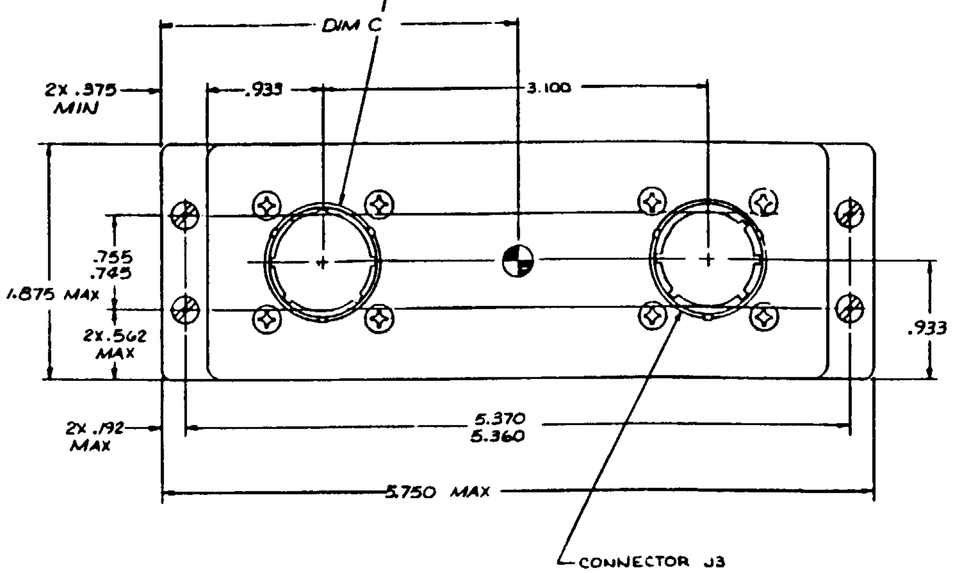
7008471-203,-204



7008471-607,-608

MODEL NO.	PART NO.	MARKINGS UNLESS OTHERWISE SPECIFIED	AREA LIGHTING		MAXIMUM WEIGHT	CENTER OF GRAVITY			PANEL COLOR
			VOLTAGE	COLOR		DIM A	DIM B	DIM C	
WC 650	7003471-601 7003471-602	WHITE	5V/28V	BLU-WHT	1.9 LBS	.93	2.96	2.97	GRAY BLACK
WC 650	7008471-603	WHITE	5V/28V	BLU-WHT	1.9 LBS	.93	2.96	2.97	GRAY
WC 650	7008471-604	WHITE	5V/28V	BLU-WHT	1.9 LBS	.93	2.96	2.97	GRAY
WC-650	7008471-605	WHITE	5V/28V	BLU-WHT	1.9 LBS	.93	2.96	2.97	GRAY
WC-650	7008471-606	WHITE	5V/28V	BLU-WHT	1.9 LBS	.93	2.96	2.97	BLACK
WC-650	7008471-607	WHITE	5V/28V	BLU-WHT	1.9 LBS	.93	2.96	2.97	GRAY
WC-650	7008471-608	WHITE	5V/28V	BLU-WHT	1.9 LBS	.93	2.96	2.97	BLACK
WC-650	7008471-201	WHITE	5V/28V	BLU-WHT	1.9 LBS	.93	2.96	2.97	GRAY
WC-650	7008471-202	WHITE	5V/28V	BLU-WHT	1.9 LBS	.93	2.96	2.97	BLACK
WC-650	7008471-203	WHITE	5V/28V	BLU-WHT	1.9 LBS	.93	2.96	2.97	GRAY
WC-650	7008471-204	WHITE	5V/28V	BLU-WHT	1.9 LBS	.93	2.96	2.97	BLACK
WC-650	7008471-622	WHITE	5V/28V	GRN(NVIS)	1.9 LBS	.93	2.96	2.97	BLACK

CONNECTOR J1
MS27508E14B18P
HONEYWELL PN 7008493-85 OR EQUIVALENT
MATES WITH MS27473E14B35S WITH
MS27506-B14-2 STRAIN RELIEF
HONEYWELL PN 4011518-85 OR EQUIVALENT
7008471-601 TO -608, -201 TO -204.



CONNECTOR J3
MS27508E14B18PB
HONEYWELL PN 7008493-87 OR EQUIVALENT
MATES WITH MS27473E14A18SB WITH
MS27506-B14-2 STRAIN RELIEF
HONEYWELL PN 4011518-87 OR EQUIVALENT
7008741-605, -606, -201, -202.

E7007701-1, 3-N

Controller Outline and Installation Drawing
Figure 6-3

H. AIRCRAFT INTERFACE

Interconnect drawings are shown for three possible system configurations in Figure 6-4. As shown in Figure 6-4, for a stand-alone system an Indicator and an RTA are used. The Indicator is used for display and control.

Figure 6-4 also shows a dual EFIS, MFD, and single Controller system with a Controller and with dual EFIS and MFD for display.

Finally, Figure 6-4 shows a dual EFIS, MFD, and dual Controller system. The left-side display is controlled by the left-side Controller and is updated when the antenna sweeps left. The right-side display is controlled by the right-side Controller and is updated when the antenna sweeps right.

The RTA receives 2-wire pitch and roll stabilization inputs, and one of three possible reference inputs: 10 V rms, 26 V rms, or 115 V rms, from the aircraft Vertical Reference System. In -921, -922, -721, and -722 units, if ARINC 429 Stabilization is used, these signals are not used.

There are three unidirectional 2-wire control bus inputs and three 2-wire picture bus outputs for the three possible displays to be connected to the RTA.

Additionally, there are two 2-wire bidirectional control buses, (primary and alternate) for use in the dual control mode to connect to the radar system Controller(s).

Four open/ground discretes are:

- RTA P201-S, GND for Inverted Mount (Fan Up) For all dash No.
- RTA P201-P, GND for 200 mV/Deg Stab
- RTA P201-R, GND to Disable full time REACT Compensation in WX mode
- RTA P201-T, Gnd for Dual Control (-90X, -91X Only)

The RTA provides a 60 milliampere current sink when the modulator is on. The Indicator provides a 60 milliampere current sink when a fault is detected.

The Controller and Indicator have two open/ground discretes: FSB1 and FSB2, either of which will force the RTA into Standby mode when grounded. If, in a dual control installation, both of these switches are wired to the weight-on-wheels switch, Forced Standby must be overridden at both Controllers. To accomplish this, both RANGE pushbuttons on each Controller must be pressed simultaneously.

In addition, two maintenance switches (see Figure 6-5) which are accessible through the RTA base are provided:

NOTE: When switching the SCAN and XMTR switches on the RTA housing to the OFF position, the RTA processor recognizes a SCAN and transmitter failure and sets the SCAN and AFC fault BITS. When entering the hidden maintenance pages a history of the faults which have occurred is provided. The fault memory may be cleared by grounding main connector J201 pin E prior to power-up, or an alternate method is to turn the system on/off seven times to clear the maintenance pages.

XMTR - disables the transmitter in the OFF position
SCAN - disables antenna azimuth scan in OFF position

I. CONNECTOR PIN LAYOUTS

Connector pin layouts are given in Figure 6-6.

J. USE OF FILLER WIRES IN CRIMP CONNECTIONS

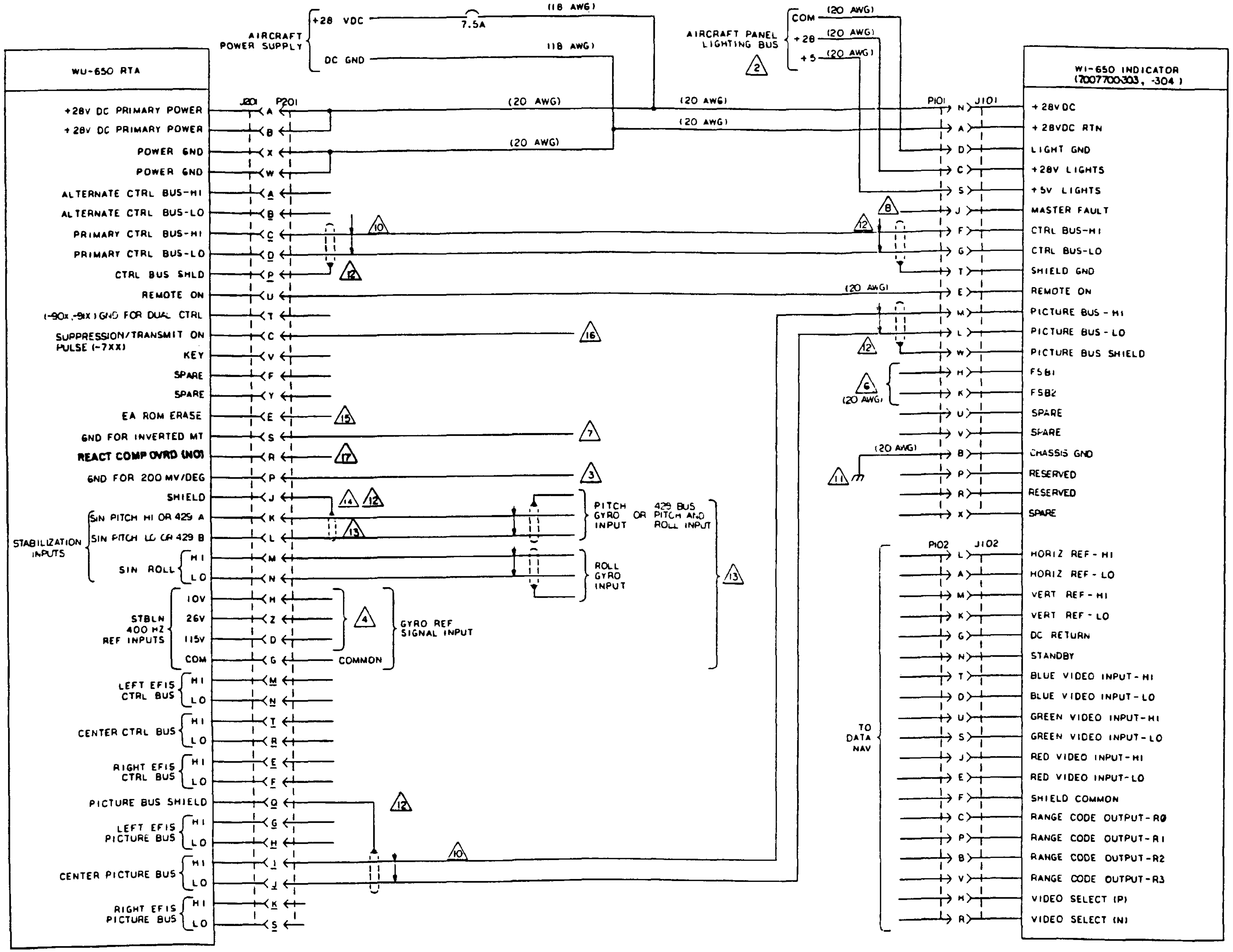
In order to reduce metal fatigue and cracking of crimp barrels, a wire size should be chosen in accordance with the requirements of the contact specification. If a wire size is required which is smaller than that authorized by the contact specification, a filler must be used. In choosing the filler wire size, several criteria must be met.

- The size of the filler wires should not differ from the size of the principal wire(s) by more than four wire gauges, e.g., 24 AWG to 28 AWG.
- The sum of the circular-mil area of the wires to be crimped must exceed 25 percent of the circular-mil area of the crimp barrel. It is advantageous to fill the barrel to a maximum, consistent with the amount of effort and time necessary to insert the wires, but in any case the "percent fill" should be greater than 25 percent.

To choose the combination of wires which will result in the optimum crimp, a filler wire not more than 4 AWG larger than the principal wire should be inserted into the crimp barrel. If, after inserting the filler wire and the principal wire(s), the barrel could still have received more wires, then two fillers, using smaller gauge wires, should be tried as necessary until a combination is achieved which meets the "percent fill" criteria as follows:

$$\frac{\text{Sum of Circular-mil areas of all wires}}{\text{Circular-mil area of crimp barrel}} \times 100 > 25.$$

NOTE: Derived from M2595358-K.



NOTES:

1. ALL WIRE NO. 22 AWG UNLESS OTHERWISE SHOWN.

△2 EITHER 28VDC OR 5V AC/DC PANEL LIGHTING MAY BE USED. CONNECT P2-C OR P2-S ON INDICATOR, P2-G OR P2-H ON CONTROLLER, AS APPROPRIATE.

△3 STABILIZATION GRADIENT MAY BE EITHER 50MV/DEGREE OR 200MV/DEGREE. GROUND THIS PIN FOR 200MV/DEGREE. LEAVE OPEN FOR 50MV/DEGREE.

△4 GYRO DEMODULATION REFERENCE SIGNAL MAY BE EITHER 10V, 26V, OR 115V, 400HZ. ONLY ONE INPUT SHALL BE CONNECTED.

5. CONNECTOR PART NUMBERS:
RTA: A1J1-HPN 4006011-1
P1-MS3126F20-41S (HPN 4000809-606)

INDICATOR: J101-HPN 7007695-1
P2 - MS3126F22-21S (HPN 4000809-621)
J102-SPN 7008861-46
P3-MS3126F14-19S (HPN 4000809-546)

CONTROLLER: A2J1-MS27508E14B18P (HPN 7005958-85)
P2-MS 27473E14B18S WITH MS27506-B14-2
STRAIN RELIEF (HPN 4011518-85).

△6 A GROUND ON FSB1 OR FSB2 WILL FORCE RTA INTO STANDBY. FORCED STANDBY MAY BE OVERRIDDEN BY SIMULTANEOUSLY DEPRESSING BOTH RANGE SELECT PUSH BUTTONS. IF BOTH CONTROLLERS ARE GROUNDED, BOTH MUST BE OVERRIDDEN

△7 P1-S SHALL BE OPEN FOR NORMAL MOUNTING, GROUND P1-S WHEN WU-650 IS MOUNTED IN INVERTED CONFIGURATION.

△8 WILL SINK 60 mA WHEN FAULT IS PRESENT. MAXIMUM PULL-UP VOLTAGE OF +60 VDC PERMITTED.

9. THE LETTERS UNDERSCORED ARE LOWER CASE.

△10 USE SPN 3718911-1 OR EQUIVALENT WIRE. INPEDANCE IS 70 Ω ±10% AND LENGTH IS LESS THAN 50 FEET.

△11 THE CHASSIS GROUND WIRE SHOULD TIE TO THE AIRCRAFT FRAME GROUND USING AWG 20 STRANDED WIRE. THE WIRE LENGTH SHOULD BE HELD TO THE MINIMUM LENGTH NECESSARY TO ASSURE PROPER ELECTRICAL CONTACT.

△12 THE INDICATED TWISTED SHIELDED PAIRS SHALL USE FILLER WIRE TO PROVIDE FOR PROPER CRIMP CONNECTIONS IN ACCORDANCE WITH M2595358: P101-F,G,T; P101-M,L,W; P201-p, c, d; P201-J,K,L; P201-q,i,j; AND P201-ghks.

△13 ON 921 AND 922 UNITS, WHEN 429 BUS STABILIZATION INPUTS ARE USED: P201-K AND L ARE USED FOR 429 A AND B; P201-M,N,H,D,G, AND Z ARE LEFT OPEN

△14 SHIELD GROUNDED AT J201-J ONLY WHEN DIGITA STABILAZION IS USED

△15 FOR BENCH USE ONLY: GROUND MOMENTARILY DURING POWER-UP TO ERASE FAULT MEMORY.

△16 TRANSMIT ON IS USED IN -9XX UNITS. IT IS AN ACTIVE LOW OUTPUT CAPABLE OF SINKING 60 mA. A MAXIMUN PULL-UP VOLTAGE OF +60 VDC PERMITTED. WHEN MAGNETRON IS OFF, TRANSMIT ON IS OPEN. ON -91X AND HIGHER UNITS, AN EMBEDDED TRIGGER PULSE GOES HIGH DURING PW. SUPPRESSION PULSE IS USED ON -7XX UNITS. IT PRODUCES A +5V PULSE WHICH GOES HIGH 200 NSEC MIN. BEFORE THE LEADING EDGE OF PW AND GOES LOW 200 NSEC MIN. AFTER TRAILING EDGE OF PW AND SOURCES 20 MA.

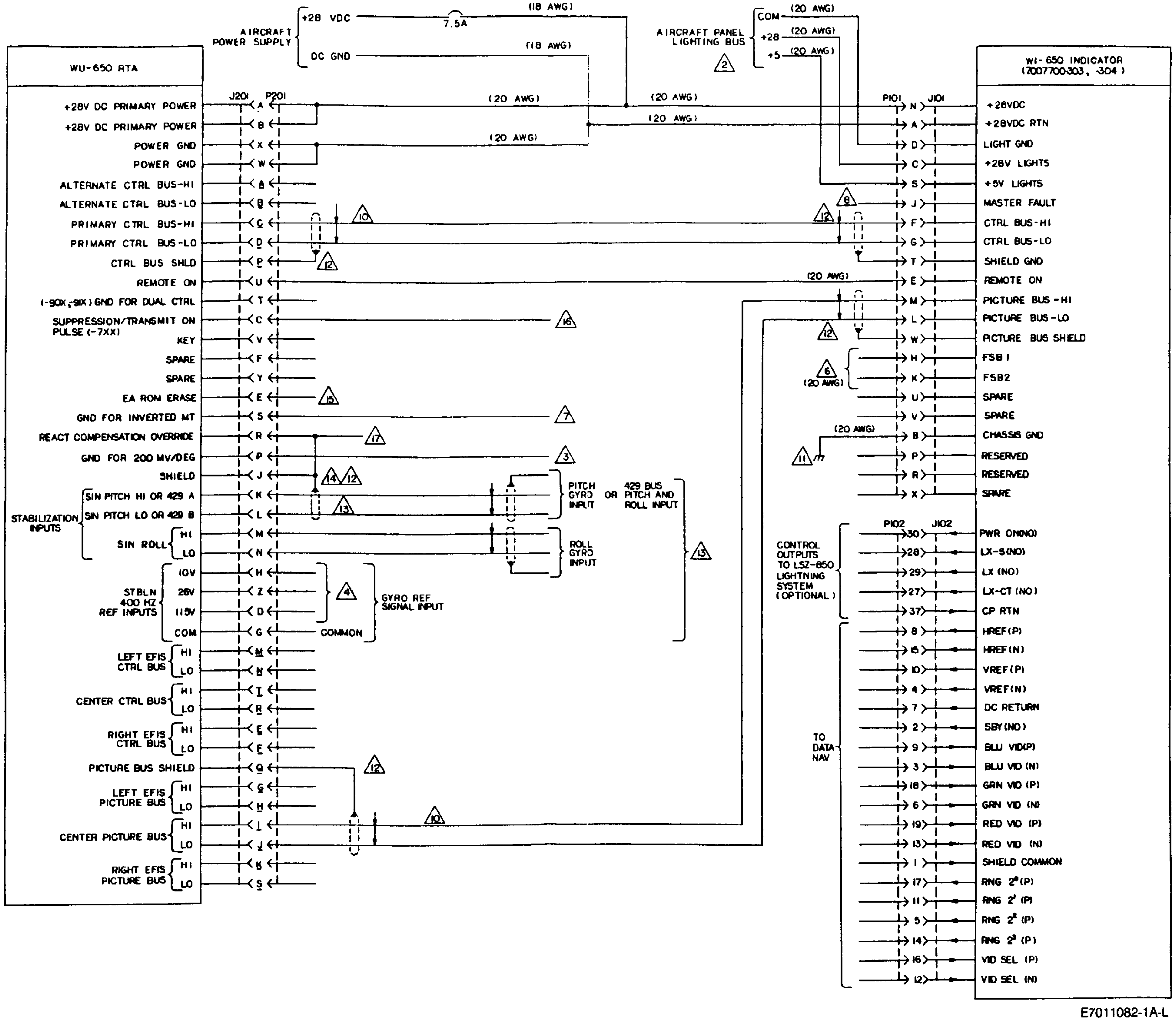
△17 A GROUND ON P201-R PREVENTS REACT COMPENSATION IN WX MODE UNLESS REACT IS MANUALLY SELECTED ON CONTROLLER OR INDICATOR. AN OPEN FORCES REACT COMPENSATION ANYTIME WX IS SELECTED. IT IS RECOMENDED THAT THIS PIN BE GROUNDED.

△18 LIGHTNING SYSTEM CONTROLS ON WC-650 CONTROLLER, PART NUMBERS 7008471-605 AND -606.

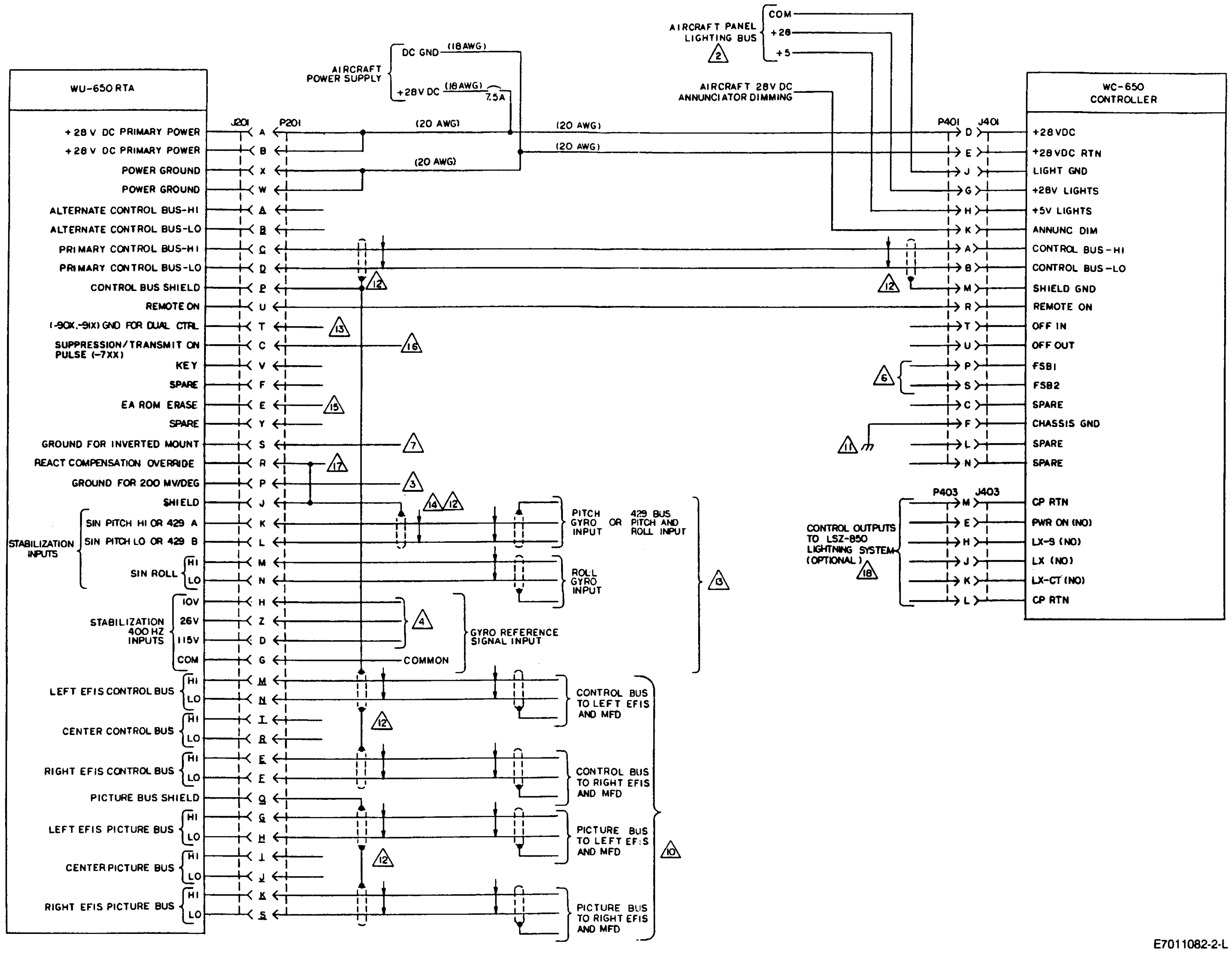
STAND-ALONE SYSTEM INTERCONNECT DIAGRAM
WI-650, PART NUMBER 7007700-303 OR -304.

E7011082-1-L

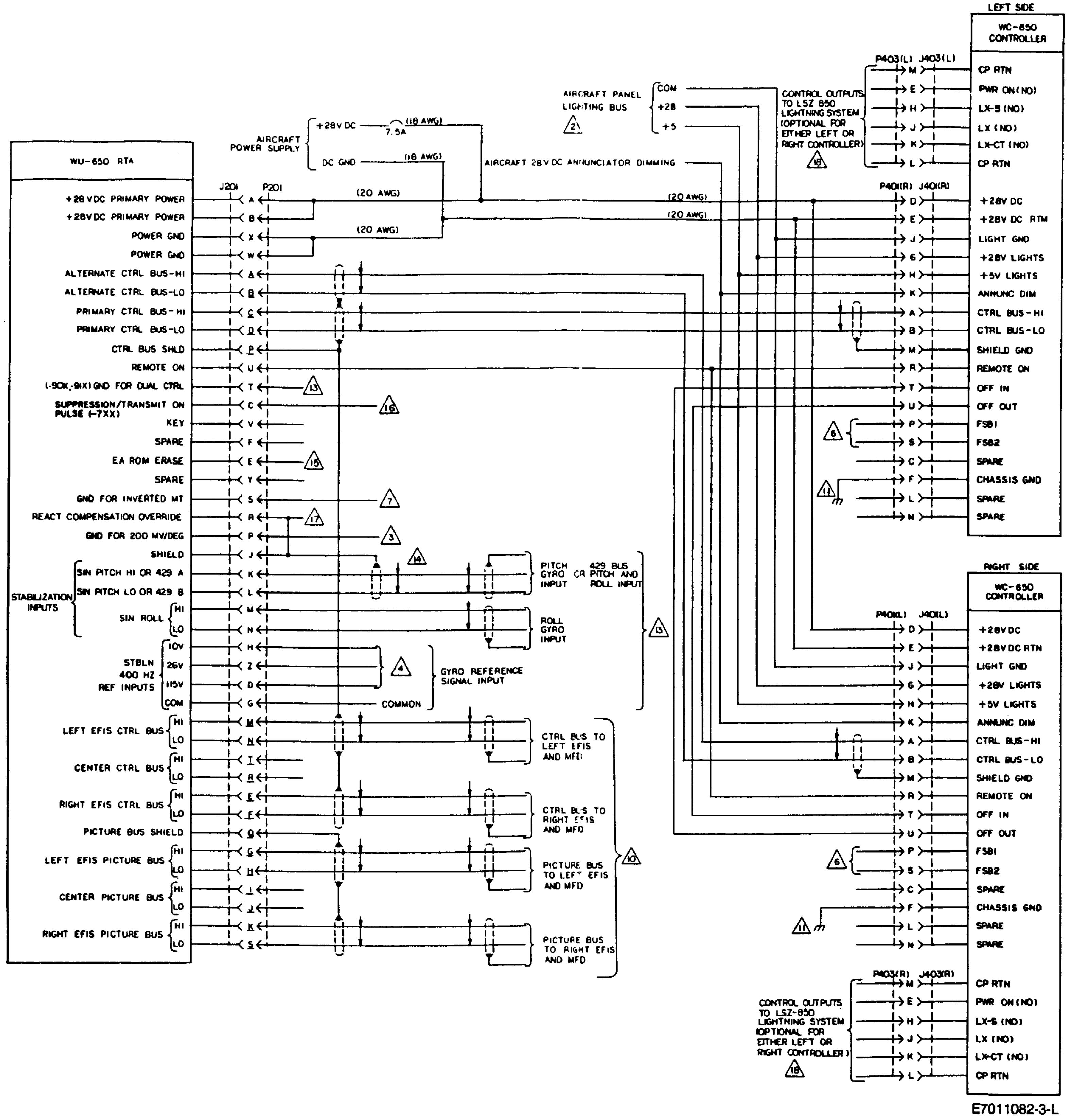
System Interconnect Diagrams
Figure 6-4 (Sheet 1)



System Interconnect Diagrams
Figure 6-4 (Sheet 2)

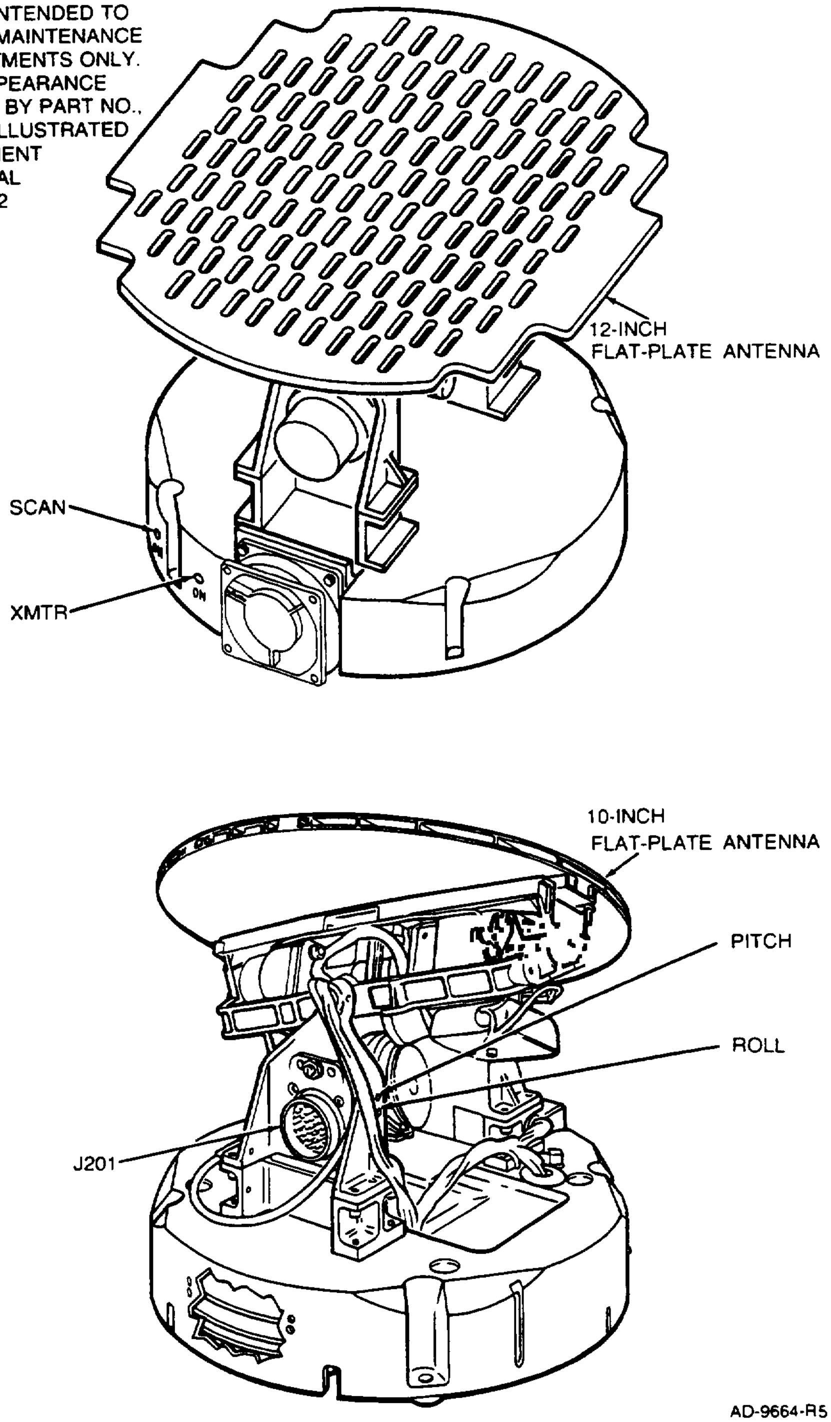


System Interconnect Diagrams
Figure 6-4 (Sheet 3)

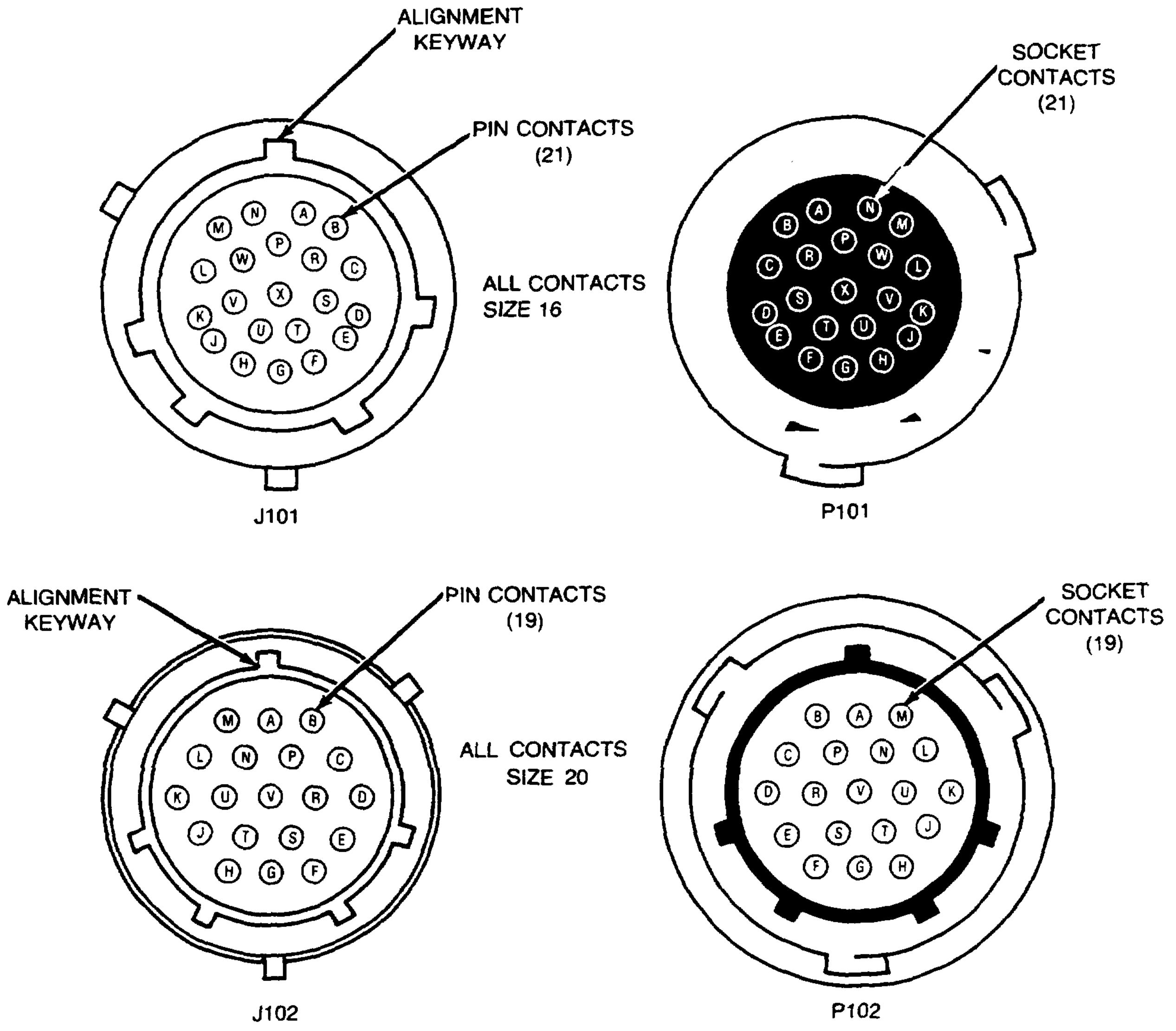


System Interconnect Diagrams
Figure 6-4 (Sheet 4)

NOTE: THIS ILLUSTRATION IS INTENDED TO SHOW LOCATIONS OF MAINTENANCE SWITCHES AND ADJUSTMENTS ONLY. TO DETERMINE THE APPEARANCE OF THE VARIOUS RTA'S BY PART NO., SEE FIGURE 1 OF THE ILLUSTRATED PARTS LIST IN COMPONENT MAINTENANCE MANUAL PUB. NO. A09-3941-02

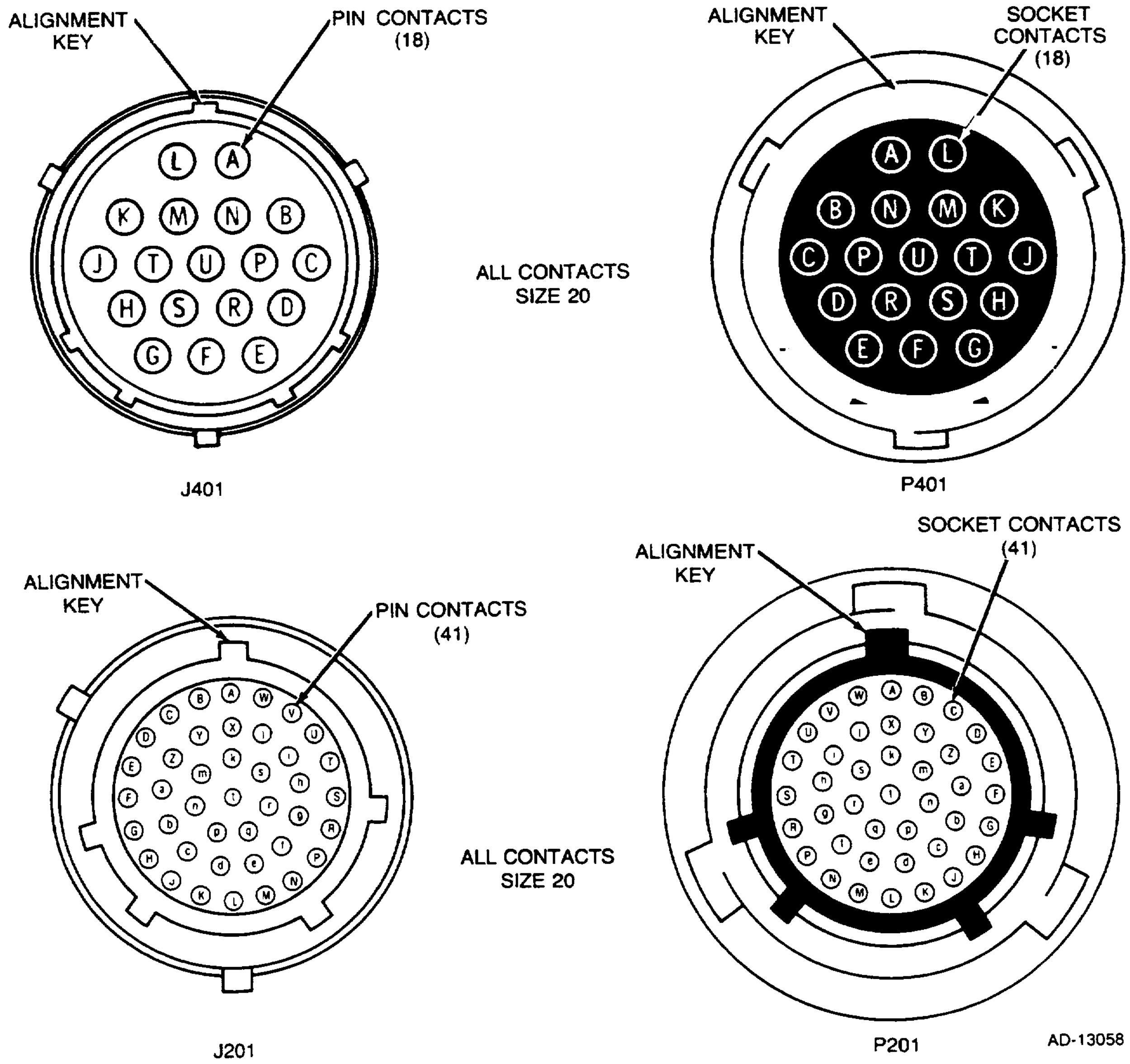


Location of RTA Maintenance Switches and Adjustments
Figure 6-5



NOTE: CONNECTORS ARE NOT NECESSARILY DRAWN TO SCALE.

Connect Pin Layouts
Figure 6-6 (Sheet 1 of 2)



Connect Pin Layouts
Figure 6-6 (Sheet 2)

SECTION 7

TEST/ADJUSTMENT

A. GENERAL

The following procedures are designed for checking the operation of the PRIMUS® 650 COLORADAR system in order to verify the installation and to perform system adjustments.

The system may be operated with one of two control sources: one with an Indicator, and one with the Controller(s) and no Indicator.

B. OPERATIONAL CHECKOUT: WITH INDICATOR

The following paragraphs provide procedures for operation and checkout of the radar when operation is at the Indicator.

1. Preliminary Control Settings

Place the system controls on the Indicator in the following positions before applying power from the aircraft electrical system:

Mode	Fully counterclockwise in OFF position
BRT	Fully counterclockwise
GAIN	Fully counterclockwise with control pushed in
TILT	Fully clockwise to +15 position

2. Precautions

If radar is to be operated in any mode other than SBY while the aircraft is on the ground:

(a) Direct nose of aircraft so that antenna scan sector is free of large metallic objects such as hangars or other aircraft for a distance of 100 feet, and tilt antenna fully upwards.

(b) Avoid operation during refueling of aircraft or other refueling operations within 100 feet.

(c) Avoid operation if personnel are standing too close in the 270-degree forward sector of the aircraft. (Refer to Maximum Permissible Exposure Level paragraph in this manual.)

B. 3. Self-Test Displays

A distinctive test pattern is displayed when the TST mode is selected. The following procedures should be performed to verify the operational status of the radar.

WARNING

TRANSMITTER OUTPUT POWER IS RADIATED THROUGHOUT THIS CHECKOUT PROCEDURE. THE TRANSMITTER CAN BE DISABLED BY SETTING THE XMTR SWITCH TO OFF, WHICH WILL CAUSE A BROKEN NOISE BAND AND AN AFC FAILURE TO BE DISPLAYED.

(a) Verify that the preliminary control settings have been made; rotate Mode control to SBY to turn system on; rotate brightness control clockwise until the display is visible. Verify that WAIT is displayed in Mode Field and that 100 is displayed as selected range.

NOTE: A time delay circuit prevents the transmitter from operating until the magnetron has warmed up. The radar will display WAIT and will be in standby for the 45-second warm-up period. It then automatically becomes operational in the selected mode.

(b) Rotate the Mode control to TST. When the test pattern appears, verify operation of the brightness (BRT) control and adjust to desired viewing level.

NOTE: If either of the Forced Standby pins of the Indicator has been wired to a weight-on-wheels switch, the Indicator will stay in forced Standby as long as the aircraft is on the ground, unless both RANGE pushbuttons are pressed simultaneously to override Forced Standby.

(c) Observe the display; verify that TEST is displayed in the Mode Field and that test pattern exhibits the following characteristics. (See Figure 3-4.)

- Range marks and alphanumerics are displayed in white.
- Color bar is displayed below the Mode Field.
- The colors of the first three target bands are green, yellow, and red.
- The color of the fourth target band (50 to 60 NM) is magenta.
- The 10 NM wide noise band beginning at 80 NM is predominantly green, but may contain some yellow and red dots, and extends unbroken across the full display.

B. 3. (d) Observe the noise band and the update line where the noise is changing in synchronism with the antenna scan. Press the TGT pushbutton when the update line is at one end of the sweep and verify that a green T appears in the Target Alert Field. Verify that when the update line passes through the dead-ahead position, the green T changes to a black TGT on a yellow background and a red block is centered in the test pattern. Press the TGT pushbutton again to disable the function.

(e) Verify that 100 is displayed in the upper right-hand corner and that the first four range marks are labeled with the correct numerics.

(f) Press the RANGE▲ pushbutton twice. Verify that the range remains at 100 NM.

(g) Press the AZ pushbutton and verify that azimuth marks are displayed at 30° intervals. Press the AZ pushbutton again to remove azimuth marks.

(h) Pull GAIN control outward and verify that the color bar legend remains in numeric display mode and does not display VAR.'. Press GAIN control inward to the preset position.

(i) Pull the TILT knob out for STAB OFF. Verify that the STAB OFF annunciator is displayed in the upper left-hand corner. Press the TILT knob inward to the stabilization position and verify STAB OFF annunciator disappears.

(j) Press the RCT pushbutton and verify that RCT is displayed above the Mode Field. Verify that the color of the RCT Field is cyan and appears between the magenta color band and the noise band. The noise band should change colors to magenta. Verify that the RCT annunciator disappears when the RCT pushbutton is pressed again.

(k) Press the SCT pushbutton and verify that the displayed scan is reduced to a 60-degree sector with a scan rate of approximately 1 sweep every 2 seconds. Press the SCT pushbutton again to restore the 120-degree scan with a scan rate of approximately 1 sweep every 4 seconds.

(l) Rotate the Mode control to the ON position and verify that WX appears in the Mode Field. Verify that the color of the range marks and alphanumerics is white.

(m) Press the RANGE▲ pushbutton and verify that the selected range increases with each press in the sequence:

100-200-300-5-10-25-50-REPEAT.

Press the RANGE▼ pushbutton and verify that the selected range decreases in the reverse sequence:

100-50-25-10-5-300-200-REPEAT.

B. 3. (n) Press the TGT pushbutton and verify that the target enable annunciator T is displayed. Verify that the T annunciator disappears when the TGT pushbutton is pressed again.

(o) Press the RCT pushbutton and verify that RCT is displayed above the Mode Field. Pull the GAIN control outward and verify that the color-bar legend remains in the numeric display mode and does not display VAR.'. Press the RCT pushbutton again and verify that the RCT annunciator disappears and that the color-bar legend displays VAR..

Press the GAIN control inward to the preset position and verify the color bar returns to the numeric legend.

(p) Repeat steps (g), (i), and (k) for azimuth marks, STAB OFF, and sector select verification.

(q) Press the GMAP pushbutton. Verify that the color of the range marks and alphanumerics is green, and that GMAP appears in the Mode Field.

(r) Press the RCT pushbutton and verify that the RCT annunciator does not display after the RCT pushbutton activation. Pull the GAIN control outward and verify that the color-bar legend displays the VAR. legend. Press the GAIN control inward to the preset position and verify that the color bar returns to the numeric legend.

(s) Repeat steps (g), (i), (n), and (k) for azimuth marks, STAB OFF, RANGE annunciations, and SCT select respectively.

(t) Press the TGT pushbutton and verify that T or TGT annunciators are not displayed after the TGT pushbutton activation.

(u) Make note of the selected range, then select FP. Range and azimuth markers will turn cyan and 100 NM range will be displayed (on first entry into FP mode).

Use RANGE and RANGE pushbuttons to select ranges and observe that ranges of 5-10-25-50-100-200-300-500-1000 are available. Select a range other than the one noted above. Select ON, and observe that the previously noted range is now displayed.

(v) Select the FP mode once again and repeat steps (g), (i), (k), and (n) for azimuth marks, STAB OFF, SECTOR SELECT, and TARGET ALERT respectively.

(w) Press the RCT pushbutton and verify that the RCT annunciator does not display after the RCT pushbutton activation.

C. OPERATIONAL CHECKOUT: WITH CONTROLLER(S)

The following paragraphs provide procedures for operation and checkout of the radar when operation is from the Controller(s). The Controller(s) is/are required when there is no Indicator in the system. In this case, the Controller(s) provide(s) the necessary control and the display is at the EFIS and/or MFD. Single or dual Controllers may be used. With one Controller, both directions of the antenna sweep are under the same control and all radar displays are identical. With two Controllers the pilot and copilot can control range, gain, tilt, and mode independently for display on the EFIS. This is accomplished by time-sharing the RTA. The pilot can select the operating parameters so that the left-to-right antenna scan and the RTA circuits follow those commands and update the EFIS. The copilot can select different operating parameters so that the alternate antenna scan and the RTA circuits follow those commands and update the right-side EFIS.

Slaving one Controller to the other is accomplished by selecting OFF on the Controller that is to be slaved. The result is that the opposite-side Controller commands its range, mode, gain, and tilt selections for both antenna sweeps and all radar displays are identical. The SLV annunciator indicates this condition.

1. Preliminary Control Settings

Place the system controls on the Controller(s) in the following positions before applying power from the aircraft electrical system:

MODE	OFF
GAIN	Fully counterclockwise
TILT	Fully clockwise to +15 position
Function	WX (-601 thru -604, -622 Only)

2. Precautions

If radar is to be operated in any mode other than STBY while the aircraft is on the ground:

(a) Direct nose of aircraft so that antenna scan sector is free of large metallic objects such as hangars or other aircraft for a distance of 100 feet and tilt antenna fully upwards.

(b) Avoid operation during refueling of aircraft or other refueling operations within 100 feet.

(c) Avoid operation if personnel are standing too close in the 270-degree forward sector of the aircraft. (Refer to Maximum Permissible Exposure Level paragraph in this manual.)

C. 3. Displays

(a) Set Controller No. 1 MODE control to STBY.

(b) Check that the SLV annunciator on Controller No. 2 (if fitted) is lighted.

(c) Set Controller No. 2 (if fitted) MODE control to STBY and the MODE control on Controller No. 1 to OFF.

(d) Check that the SLV annunciator on Controller No. 1 is lighted.

(e) Select remaining Controller functions for display on the EFIS and/or MFD and check in accordance with the appropriate EFIS and/or MFD technical manual.

D. ADJUSTMENT OF STABILIZATION INPUT

1. Preliminary Checks

(a) Level the pitch and roll reference axes of the aircraft relative to the earth's surface.

(b) Verify that the mounting surface of the RTA is aligned to the pitch and roll reference axes of the aircraft within ± 1/4 degree.

2. Elevation Feedback Check

Verify, in the Standby mode, that the flat-plate radiator is up 15 degrees. If not, adjust elevation feedback potentiometer R1 for a 15 ± 1/2 degree up-tilt, perpendicular to the RTA mounting surface.

NOTE: When switching the SCAN and XMTR switches on the RTA housing to the OFF position, the RTA processor recognizes a SCAN and transmitter failure and sets the SCAN and AFC fault BITS. When entering the hidden maintenance pages a history of the faults which have occurred is provided. The fault memory may be cleared by grounding main connector J201 pin E prior to power-up, or an alternate method is to turn the system on/off seven times to clear the maintenance pages.

3. Pitch Gain Adjustment/Check

(a) Set SCAN and XMTR switches, on RTA housing, to OFF (toward antenna) and select Standby on the Controller or Indicator. The RTA is now in pitch and roll calibration mode.

D. 3. (b) Select preset GAIN. This forces a 0-degree condition in azimuth by the processor. Azimuth position of the antenna does not matter in calibration mode.

(c) Adjust TILT control on Indicator or Controller for 0-degree on the face of the flat-plate radiator with an inclinometer (for a dual installation left Controller only).

(d) Adjust vertical reference for 25 degrees of nose-up pitch and 0 degree of roll. The pitch and roll gain potentiometers are accessible through holes in the stand next to the RTA main connector. (See Figure 6-5.)

NOTE: If AHRS is used, pushing AHRS test button simulates 10 degree nose up pitch and 20 degrees of right roll.

(e) Adjust the front potentiometer (PITCH) (fan is down) A4A1R3 if necessary, so that the antenna tilts down 25 degrees in elevation while manual GAIN is in preset.

NOTES: 1. In systems with digital stabilization input to the RTA, verify that the antenna tilts down 25 ± 1.5 degrees. In these systems, the pitch gain potentiometer has no effect.

2. Do not displace the vertical reference from its level position for more than a few seconds at a time; otherwise, precession may occur and introduce errors which prevent correct adjustment. After each displacement from level position, re-level the gyro for several minutes before proceeding to the next check.

4. Roll Gain Adjustment/Check

(a) Verify that the GAIN control is out of the preset position. This will force a 90-degree right azimuth condition by the processor.

(b) Adjust the vertical reference for 0 degree of pitch and 25 degrees of right-roll.

NOTE: If AHRS is used, pushing AHRS test button simulates 10 degree nose up pitch and 20 degrees of right roll.

(c) Adjust the rear potentiometer (ROLL) A4A1R4 (see Figure 6-5) if necessary, so that the antenna tilts up 25 degrees in elevation.

NOTE: In systems with digital stabilization input to the RTA, verify that the antenna tilts up 25 ± 1.5 degrees. In these systems the roll gain potentiometer has no effect.

D. 4. (d) Return the GAIN control to preset, turn the system off, and set the SCAN and XMTR switches to ON. (See Figure 6-5.)

(e) Re-install the vertical reference in its aircraft mounting location.

5. Roll Offset Adjustment

NOTE: This is an in-flight adjustment and is accomplished with a Controller connected to the primary bus only. If two Controllers are installed, turn the secondary Controller to OFF. If an Indicator is used as the Controller, the procedure is identical to that given below.

(a) At an altitude of 10,000 feet above ground level or greater and in the 100 NM range, adjust antenna tilt down until a fairly solid band of ground clutter is visible.

(b) Select variable gain. Observe VAR! on display.

(c) Part No. 7008471-601 thru -608, -622 Only - Press RCT pushbutton once and then three more times within 4 seconds. VAR! should not be displayed. This puts the unit in roll compensation mode. Press RCT pushbutton once more and verify VAR! is not displayed. If it is, repeat step (c).

Part No. 7008471-201 thru -204 Only - Within 3 seconds, rotate Radar select switch from the WX to the WX/RCT position two times, then back to WX again. VAR! should not be displayed. This puts the unit in roll compensation mode. Rotate Radar select switch once more from the WX to the WX/RCT position. Verify VAR! is not displayed. If it is, repeat step (c).

(d) Adjust manual GAIN control on Controller until the ground clutter display is symmetrical.

(e) Do not touch manual GAIN control once display is adjusted properly.

(f) Part No. 7008471-601 thru -608, -622 Only - Press RCT pushbutton once and then three more times within 4 seconds to exit the roll compensation mode. When VAR! is displayed again, the roll compensation mode has been exited. Set variable or preset GAIN as desired.

Part No. 7008471-201 thru -204 Only - Within 3 seconds, rotate Radar select switch from the WX to WX/RCT position two times, then back to WX again. When VAR! is displayed again, the roll compensation mode has been exited. Set variable or preset GAIN as desired.

SECTION 8

CHECK

A. GENERAL

The following check procedures are recommended for the PRIMUS® 650 COLORADAR system after it is installed in the aircraft.

B. EQUIPMENT AND MATERIALS

None

C. PROCEDURE

CAUTION: BEFORE PERFORMING ANY OF THESE PROCEDURES, MAKE CERTAIN THAT ALL POWER HAS BEEN REMOVED.

1. Check RTA.
    - (a) Make visual check of all external surfaces for possible damage. Check dust cover air vents and external connectors for dust, corrosion, or damage.
    - (b) Check external parts for loose or damaged hardware.
    - (c) Make visual check of fuseholder and connector covers for damage.
2. Check Indicator.
    - (a) Make visual examination of all external surfaces for possible damage. Check dust cover air vents and external connectors for dust or damage.
    - (b) Check external parts (connectors, control knobs) for looseness or damage.
    - (c) Check controls for smooth, positive action.
    - (d) Check that indicator is secure in mounting tray (locking mechanism is engaged properly).

C. 3. Check Controller.

(a) Check external parts (connectors, control knobs) for looseness or damage.

(b) Check controls for smooth, positive action.

SECTION 9

CLEANING/PAINTING

A. GENERAL

While the radar system is installed in the aircraft, cleaning is limited to the procedures given below. Painting and more extensive cleaning should be accomplished during overhaul when each LRU can be disassembled; detailed instructions are presented in the applicable component maintenance manual.

B. EQUIPMENT AND MATERIALS

Recomended cleaning agents and materials are:

- Soft brush
- Lint-free absorbent cloth
- Solvent (denatured alcohol or commercial equivalent)
- Mild glass cleaner
- Compressed air - moderate pressure
- No. 600 abrasive paper (nonconductive abrasive)

C. PROCEDURE

1. Clean RTA.
   - (a) Disconnect connector cables and remove unit.
   - (b) Clean unit with cloth or brush dampened in solvent; dry with cloth or compressed air.
   - (c) Clean all dust and foreign matter from unit connectors using cloth or brush dampened in solvent; dry with cloth or compressed air. Clean corroded connector pins with abrasive paper.
2. Clean Indicator.
   - (a) Disconnect cables, and remove Indicator.
   - (b) Clean unit with cloth or brush dampened in solvent; dry with cloth or compressed air.

C. 2. (c) Clean all dust or foreign matter from dust cover air vents and rear connector with cloth or brush dampened in solvent; dry wih cloth or compressed air.

(d) Clean front panel and face of Indicator with mild glass cleaner and soft cotton cloth. Do not use abrasive or solvent-type cleaners.

(e) Replace Indicator, and reconnect cables.

3. Clean Controller.

(a) Clean front panel of Controller with mild glass cleaner and soft cotton cloth. Do not use abrasive or solvent-type cleaners.

(b) Use compressed air to blow away any visible dirt from controls.

4. Painting

Except for minor retouching, painting should be accomplished after the equipment has been removed from the aircraft during overhaul.

SECTION 10

APPROVED REPAIRS

Major repairs to the radar system components are made only during overhaul when the equipment is removed from the aircraft. Detailed instructions for repair and adjustment of each of the LRUs are presented in the applicable component maintenance manuals.

SECTION 11

ILLUSTRATED PARTS LIST

A. GENERAL

This section contains a list of major PRIMUS® 650 COLORADAR system LRUs. They are illustrated in Figure 11-1 and described in Table 11-1.

B. PARTS LISTING

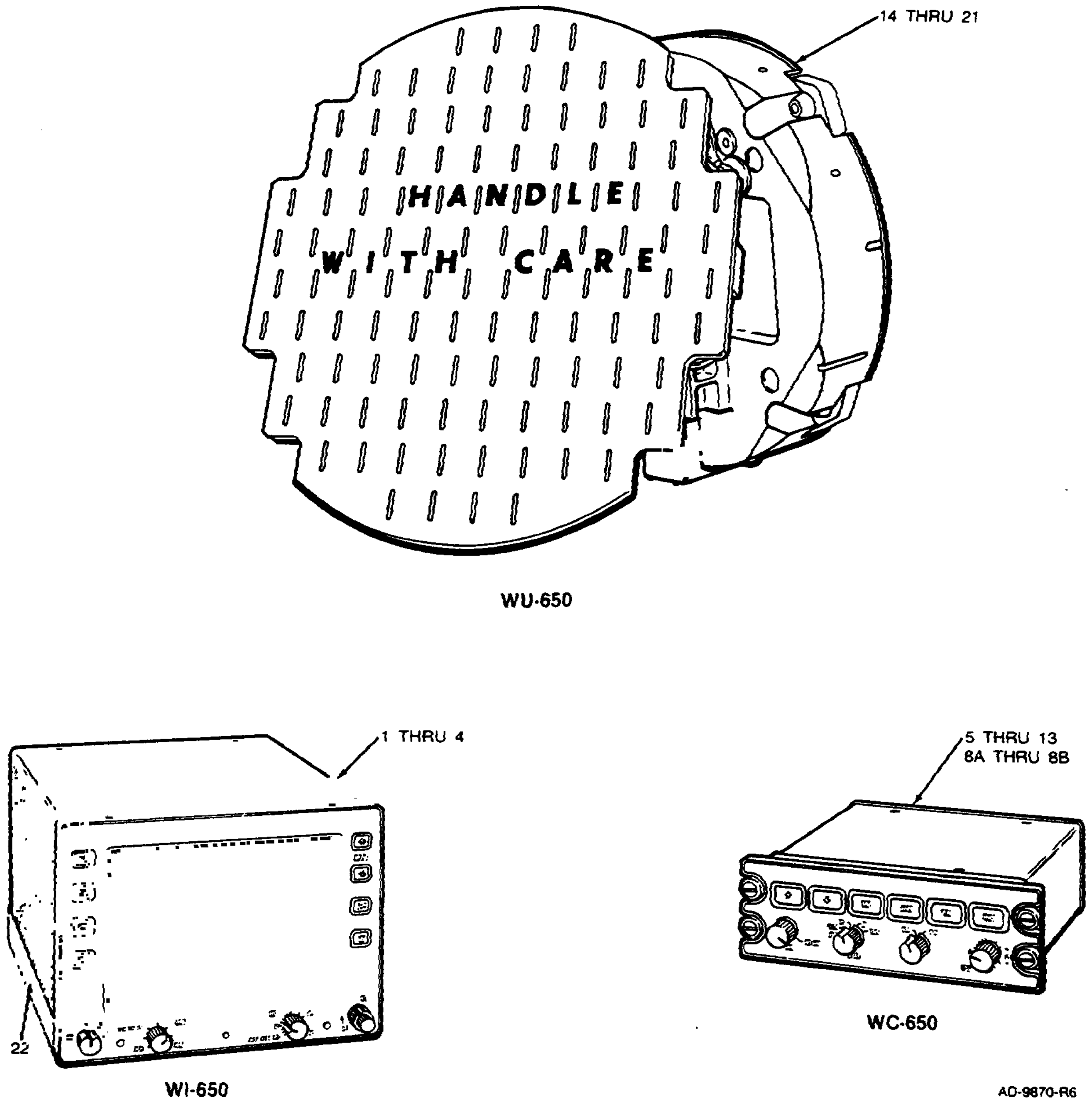
The illustrated parts list shows the units of this radar system. A detailed parts list for each of the LRUs, where applicable, is contained in the appropriate component maintenance manual. If an item listed is preceded by a dash, it is not illustrated.

C. ORDERING REPLACEMENT PARTS

When ordering replacement components from Honeywell Inc., specify the part number and component description. Address all part orders to:

Honeywell Inc.
Sperry Commercial Flight Systems
1830 Industrial Avenue
Wichita, Kansas 67216
PH: (316) 522-8172
TLX: 41-7444

ATTN: Replacement Parts



PRIMUS® 650 Units
Figure 11-1

Fig. & Item No.	Part No.	Description
11-1	7007700-301	Indicator, Gray Bezel - WI-650
2	7007700-302	Indicator, Black Bezel - WI-650
3	7007700-303	Indicator, Gray Bezel - WI-650
4	7007700-304	Indicator, Black Bezel - WI-650
5	7008471-601	Controller, Gray Bezel, Black Knobs - WC-650
6	7008471-602	Controller, Black Bezel, Black Knobs - WC-650
7	7008471-603	Controller, Gray Bezel, Gray Knobs - WC-650
8	7008471-604	Controller, Gray Bezel, Black Knobs, Minimum Range 25 Miles, - WC-650
8A	7008471-201	Controller, Gray Bezel, Black Knobs - WC-650
8B	7008471-202	Controller, Black Bezel, Black Knobs - WC-650
8C	7008471-203	Controller, Gray Bezel, Black Knobs - WC-650
8D	7008471-204	Controller, Black Bezel, Black Knobs - WC-650
9	7008471-605	Controller, Gray Bezel, Black Knobs - WC-650
10	7008471-606	Controller, Black Bezel, Black Knobs - WC-650
11	7008471-607	Controller, Gray Bezel, Black Knobs - WC-650
12	7008471-608	Controller, Black Bezel, Black Knobs - WC-650
13	7008471-622	Controller, Black Bezel, Black Knobs - WC-650
*14	7008470-901	RTA with 10-inch Flat-Plate Antenna - WU-650
15	7008470-902	RTA with 12-inch Flat-Plate Antenna - WU-650
*16	7008470-911	RTA with 10-inch Flat-Plate Antenna - WU-650
17	7008470-912	RTA with 12-inch Flat-Plate Antenna - WU-650
*18	7008470-921	RTA with 10-inch Flat-Plate Antenna - WU-650
19	7008470-922	RTA with 12-inch Flat-Plate Antenna - WU-650
*20	7008470-721	RTA with 10-inch Flat-Plate Antenna - WU-650
21	7008470-722	RTA with 12-inch Flat-Plate Antenna - WU-650
22	7011359-901	Mounting Tray for WI-650 Indicator

* Only the 12-inch Flat-Plate Antenna is illustrated.

PRIMUS® 650 Equipment
Table 11-1

Fig. & Item No.	Part No.	Description	Qty
11-23	7011070-001	Connector Kit	
	4000809-606	* Connector (RTA, P201)	1
	4000809-621	* Connector (Indicator, P101)	1
-24	7011070-002	Connector Kit	
	4000809-621	* Connector (Indicator, P101)	1
	4011518-546	* Connector (Indicator,19 Pin UDI, P102)*	1
	4000809-606	* Connector (RTA)	1
-25	7011070-003	Connector Kit	
	4000809-606	* Connector (RTA, P201)	1
	4011518-085	* Connector (Controller, P401)	1
-26	7011070-004	Connector Kit	
	4011518-085	* Connector (Controller, P401)	2
	4000809-606	* Connector (RTA, P201)	1
-27	7011070-911	Connector Kit	
	4000809-546	* Connector (Indicator, 19 Pin UDI, P102)*	1
-28	7011070-912	Connector Kit	
	4011518-095	* Connector (Indicator, 35 Pin UDI, P102)*	1
-29	7011070-013	Connector Kit	
	4011518-087	* Connector (Controller, AUX LSS Controls, P403)	1

* The 19 pin UDI connector is used on WI-650 Indicators without integral lightning sensor controls.

The 35 pin UDI connector is used on WI-650 Indicators with integral lightning sensor controls.

PRIMUS® 650 Equipment
Table 11-1 (cont)

APPENDIX A

FAA ADVISORY CIRCULARS

This section provides FAA Advisory Circulars of interest to users of airborne weather radar.

AC 20-68B

DATE 8/8/80

ADVISORY CIRCULAR

DEPARTMENT OF TRANSPORTATION
Federal Aviation Administration
Washington, D.C.

Subject: RECOMMENDED RADIATION SAFETY PRECAUTIONS FOR GROUND OPERATION OF AIRBORNE WEATHER RADAR

1. PURPOSE. This circular sets forth recommended radiation safety precautions to be taken by personnel when operating airborne weather radar on the ground.

2. CANCELLATION. AC 20-68A, dated April 11, 1975, is canceled.

3. RELATED READING MATERIAL.

a. Barnes and Taylor, Radiation Hazards and Protection (London: George Newnes Limited, 1963), p. 211.

b. U.S. Department of Health, Education and Welfare, Public Health Service, Consumer Protection and Environmental Health Service, "Environmental health microwaves, ultraviolet radiation and radiation from lasers and television receivers - An Annotated Bibliography," FS 2.300: RH-35, Washington, U.S. Government Printing Office, pp. 56-57.

c. Mumford, W. W., "Some technical aspects of microwave radiation hazards," Proceedings of the IRE, Washington, U.S. Government Printing Office, February 1961, pp. 427-447.

4. BACKGROUND. Dangers from ground operation of airborne weather radar include the possibility of human body damage and ignition of combustible materials by radiated energy. Low tolerance parts of the body include the eyes and testes.

5. PRECAUTIONS. Management and supervisory personnel should establish procedures for advising personnel of dangers from operating airborne weather radars on the ground. Precautionary signs should be displayed in affected areas to alert personnel of ground testing.

a. General.

(1) Airborne weather radar should be operated on the ground only by qualified personnel.

Initiated by: AFO-512

(2) Installed airborne radar should not be operated while the aircraft is in a hangar or other enclosure unless the radar transmitter is not operating, or the energy is directed toward an absorption shield which dissipates the radio frequency energy. Otherwise, radiation within the enclosure can be reflected throughout the area.

b. Body Damage. To prevent possible human body damage, the following precautions should be taken:

(1) Personnel should never stand nearby and in front of a radar antenna which is transmitting. When the antenna is not scanning, the danger increases.

(2) A recommended safe distance from operating airborne weather radars should be established. A safe distance can be determined by using the equations in Appendix 1 or the graphs of figures 1 and 2. This criterion is now accepted by many industrial organizations and is based on limiting exposure of humans to an average power density not greater than 10 milliwatts per square centimeter.

(3) Personnel should be advised to avoid the end of an open waveguide unless the radar is turned off.

(4) Personnel should be advised to avoid looking into a waveguide, or into the open end of a coaxial connector or line connector to a radar transmitter output, as severe eye damage may result.

(5) Personnel should be advised that when high power radar transmitters are operated out of their protective cases, X-rays may be emitted. Stray X-rays may emanate from the glass envelope type pulser, oscillator, clipper, or rectifier tubes, as well as magnetrons.

c. Combustible Materials. To prevent possible fuel ignition, an installed airborne weather radar should not be operated while an aircraft is being refueled or defueled.

M. C. BEARD
Director of Airworthiness

AC NO: 00-24A

DATE: 6/23/78

ADVISORY CIRCULAR

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

SUBJECT: THUNDERSTORMS

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1. PURPOSE. This advisory circular describes the hazards of thunderstorms to aviation and offers guidance to help prevent accidents caused by thunderstorms.

2. CANCELLATION. Advisory Circular 00-24, dated July 12, 1968, is canceled.

3. REFERENCES. Advisory Circulars 00-6A, 00-45A, and 00-50.

4. GENERAL. We all know what a thunderstorm looks like. Much has been written about the mechanics and life cycles of thunderstorms. They have been studied for many years; and while much has been learned, the studies continue because much is not known. Knowledge and weather radar have modified our attitudes toward thunderstorms, but one rule continues to be true--any storm recognizable as a thunderstorm should be considered hazardous until measurements have shown it to be safe. That means safe for you and your aircraft. Almost any thunderstorm can spell disaster for the wrong combination of aircraft and pilot.

5. HAZARDS. A thunderstorm packs just about every weather hazard known to aviation into one vicious bundle. Although the hazards occur in numerous combinations, let us look at the most hazardous combination of thunderstorms, the squall line, then we will examine the hazards individually.

a. Squall Lines. A squall line is a narrow band of active thunderstorms. Often it develops on or ahead of a cold front in moist, unstable air, but it may develop in unstable air far removed from any front. The line may be too long to detour easily and too wide and severe to penetrate. It often contains steady-state thunderstorms and presents the single most intense weather hazard to aircraft. It usually forms rapidly, generally reaching maximum intensity during the late afternoon and the first few hours of darkness.

Initiated by: AFS-224

b. Tornadoes.

(1) The most violent thunderstorms draw air into their cloud bases with great vigor. If the incoming air has any initial rotating motion, it often forms an extremely concentrated vortex from the surface well into the cloud. Meteorologists have estimated that wind in such a vortex can exceed 200 knots; pressure inside the vortex is quite low. The strong winds gather dust and debris and the low pressure generates a funnel-shaped cloud extending downward from the cumulo-nimbus base. If the cloud does not reach the surface, it is a "funnel cloud"; if it touches a land surface, it is a "tornado."

(2) Tornadoes occur with both isolated and squall line thunderstorms. Reports or forecasts of tornadoes indicate that atmospheric conditions are favorable for violent turbulence. An aircraft entering a tornado vortex is almost certain to suffer structural damage. Since the vortex extends well into the cloud, any pilot inadvertently caught on instruments in a severe thunderstorm could encounter a hidden vortex.

(3) Families of tornadoes have been observed as appendages of the main cloud extending several miles outward from the area of lightning and precipitation. Thus, any cloud connected to a severe thunderstorm carries a threat of violence.

c. Turbulence.

(1) Potentially hazardous turbulence is present in all thunderstorms, and a severe thunderstorm can destroy an aircraft. Strongest turbulence within the cloud occurs with shear between updrafts and downdrafts. Outside the cloud, shear turbulence has been encountered several thousand feet above and 20 miles laterally from a severe storm. A low level turbulent area is the shear zone associated with the gust front. Often, a "roll cloud" on the leading edge of a storm marks the top of the eddies in this shear and it signifies an extremely turbulent zone. Gust fronts often move far ahead (up to 15 miles) of associated precipitation. The gust front causes a rapid and sometimes drastic change in surface wind ahead of an approaching storm. Advisory Circular 00-50, "Low Level Wind Shear," explains in greater detail the hazards associated with gust fronts. Figure 1 shows a schematic cross section of a thunderstorm with areas outside the cloud where turbulence may be encountered.

(2) It is almost impossible to hold a constant altitude in a thunderstorm, and maneuvering in an attempt to do so produces greatly increased stress on the aircraft. It is understandable that the speed of the aircraft determines the rate of turbulence encounters. Stresses are least if the aircraft is held in a constant attitude and allowed to "ride the waves." To date, we have no sure way to pick "soft spots" in a thunderstorm.

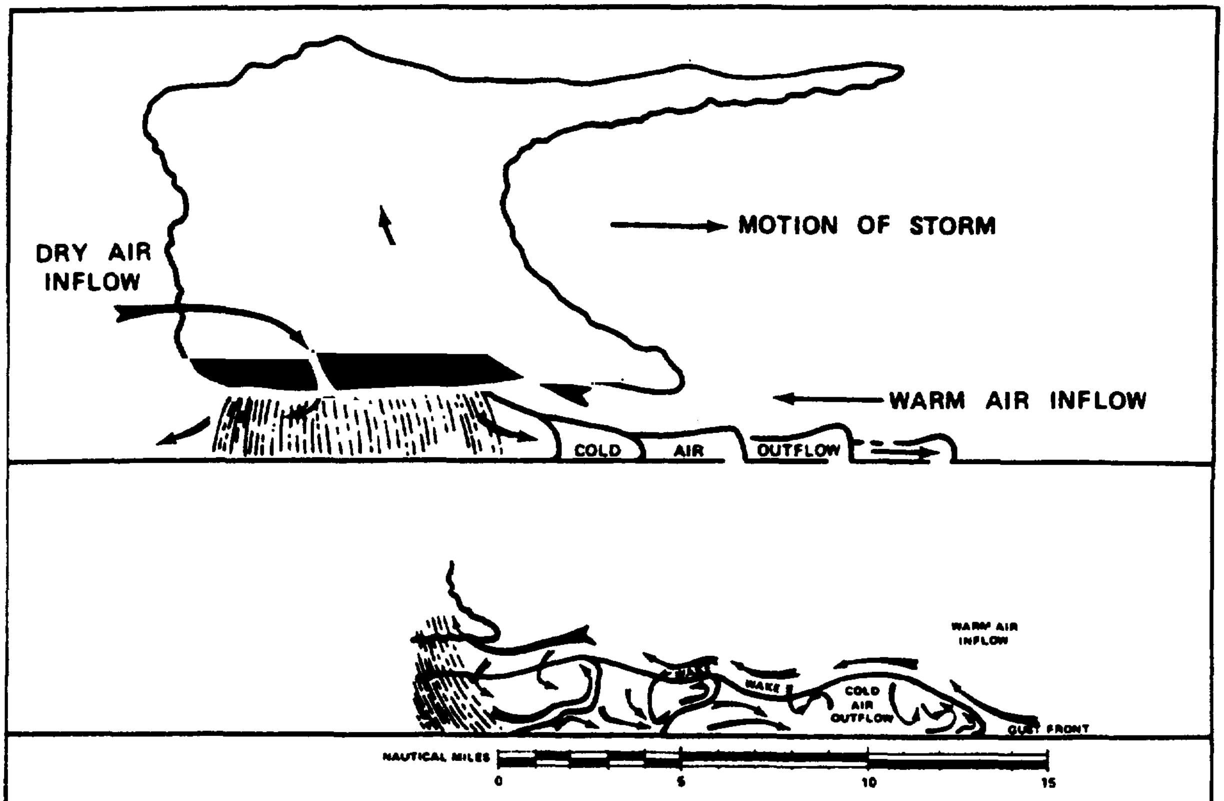

Fig. 1.

d. Icing.

(1) Updrafts in a thunderstorm support abundant liquid water; and when carried above the freezing level, the water becomes supercooled. When temperature in the upward current cools to about $-15^{\circ}C$, much of the remaining water vapor sublimates as ice crystals; and above this level, at lower temperatures, the amount of supercooled water decreases.

(2) Supercooled water freezes on impact with an aircraft. Clear icing can occur at any altitude above the freezing level; but at high levels, icing may be rime or mixed rime and clear. The abundance of supercooled water makes clear icing very rapid between $0^{\circ}C$ and $-15^{\circ}C$ and encounters can be frequent in a cluster of cells. Thunderstorm icing can be extremely hazardous.

e. Hail.

(1) Hail competes with turbulence as the greatest thunderstorm hazard to aircraft. Supercooled drops above the freezing level begin to freeze. Once a drop has frozen, other drops latch on and freeze to it, so the hailstone grows--sometimes into a huge iceball. Large hail occurs with severe thunderstorms that have built to great heights. Eventually, the

hailstones fall, possibly some distance from the storm core. Hail may be encountered in clear air several miles from dark thunderstorm clouds.

(2) As hailstones fall through air whose temperature is above $0^{\circ}C$, they begin to melt and precipitation may reach the ground as either hail or rain. Rain at the surface does not mean the absence of hail aloft. You should anticipate possible hail with any thunderstorm, especially beneath the anvil of a large cumulo-nimbus. Hailstones larger than one-half inch in diameter can significantly damage an aircraft in a few seconds.

f. Low Ceiling and Visibility. Generally, visibility is near zero within a thunderstorm cloud. Ceiling and visibility also may be restricted in precipitation and dust between the cloud base and the ground. The restrictions create the same problem as all ceiling and visibility restrictions; but the hazards are increased many fold when associated with the other thunderstorm hazards of turbulence, hail, and lightning which make precision instrument flying virtually impossible.

g. Effect on Altimeters. Pressure usually falls rapidly with the approach of a thunderstorm, then rises sharply with the onset of the first gust and arrival of the cold downdraft and heavy rain showers, falling back to normal as the storm moves on. This cycle of pressure change may occur in 15 minutes. If the pilot does not receive a corrected altimeter setting, his altimeter may be more than 100 feet in error.

h. Lightning. A lightning strike can puncture the skin of an aircraft and can damage communications and electronic navigational equipment. Lightning has been suspected of igniting fuel vapors causing explosion; however, serious accidents due to lightning strikes are extremely rare. Nearby lightning can blind the pilot rendering him momentarily unable to navigate either by instrument or by visual reference. Nearby lightning can also induce permanent errors in the magnetic compass. Lightning discharges, even distant ones, can disrupt radio communications on low and medium frequencies. Though lightning intensity and frequency have no simple relationship to other storm parameters, severe storms, as a rule, have a high frequency of lightning.

6. WEATHER RADAR.

a. Weather radar detects droplets of precipitation size. Strength of the radar return (echo) depends on drop size and number. The greater the number of drops, the stronger is the echo; and the larger the drops, the stronger is the echo. Drop size determines echo intensity to a much greater extent than does drop number. Hailstones usually are covered with a film of water and, therefore, act as huge water droplets giving the strongest of all echoes.

b. Numerous methods have been used in an attempt to categorize the intensity of a thunderstorm. To standardize thunderstorm language between weather radar operators and pilots, the use of Video Integrator Processor (VIP) levels is being promoted.

c. The National Weather Service (NWS) radar observer is able to objectively determine storm intensity levels with VIP equipment. These radar echo intensity levels are on a scale of one to six. If the maximum VIP Levels are 1 "weak" and 2 "moderate," then light to moderate turbulence is possible with lightning. VIP Level 3 is "strong" and severe turbulence is possible with lightning. VIP Level 4 is "very strong" and severe turbulence is likely with lightning. VIP Level 5 is "intense" with severe turbulence, lightning, hail likely, and organized surface wind gusts. VIP Level 6 is "extreme" with severe turbulence, lightning, large hail, extensive surface wind gusts, and turbulence.

d. Thunderstorms build and dissipate rapidly. Therefore, do not attempt to plan a course between echoes. The best use of ground radar information is to isolate general areas and coverage of echoes. You must avoid individual storms from in-flight observations either by visual sighting or by airborne radar. It is better to avoid the whole thunderstorm area than to detour around individual storms unless they are scattered.

e. Airborne weather avoidance radar is, as its name implies, for avoiding severe weather--not for penetrating it. Whether to fly into an area of radar echoes depends on echo intensity, spacing between the echoes, and the capabilities of you and your aircraft. Remember that weather radar detects only precipitation drops; it does not detect turbulence. Therefore, the radar scope provides no assurance of avoiding turbulence. The radar scope also does not provide assurance of avoiding instrument weather from clouds and fog. Your scope may be clear between intense echoes; this clear area does not necessarily mean you can fly between the storms and maintain visual sighting of them.

f. The most intense echoes are extreme thunderstorms. Remember that while hail always gives a radar echo, it may fall several miles from the nearest visible cloud, and hazardous turbulence may extend to as much as 20 miles from the echo edge. Avoid the most intense echoes by at least 20 miles; that is, echoes should be separated by at least 40 miles before you fly between them. As echoes become weak, you can reduce the distance by which you avoid them.

7. DO'S AND DON'TS OF THUNDERSTORM FLYING.

a. Above all, remember this: never regard any thunderstorm lightly, even when radar observers report the echoes are of light intensity. Avoiding thunderstorms is the best policy. Following are some do's and don'ts of thunderstorm avoidance:

(1) Don't land or takeoff in the face of an approaching thunderstorm. A sudden gust front of low level turbulence could cause loss of control.

(2) Don't attempt to fly under a thunderstorm even if you can see through to the other side. Turbulence and wind shear under the storm could be disastrous.

(3) Don't fly without airborne radar into a cloud mass containing scattered embedded thunderstorms. Scattered thunderstorms not embedded usually can be visually circumnavigated.

(4) Don't trust the visual appearance to be a reliable indicator of the turbulence inside a thunderstorm.

(5) Do avoid by at least 20 miles any thunderstorm identified as severe or giving an intense radar echo. This is especially true under the anvil of a large cumulo-nimbus.

(6) Do circumnavigate the entire area if the area has 6/10 thunderstorm coverage.

(7) Do remember that vivid and frequent lightning indicates the probability of a severe thunderstorm.

(8) Do regard as extremely hazardous any thunderstorm with tops 35,000 feet or higher whether the top is visually sighted or determined by radar.

b. If you cannot avoid penetrating a thunderstorm, following are some do's BEFORE entering the storm:

(1) Tighten your safety belt, put on your shoulder harness if you have one, and secure all loose objects.

(2) Plan and hold your course to take you through the storm in a minimum time.

(3) To avoid the most critical icing, establish a penetration altitude below the freezing level or above the level of -15°C.

(4) Verify that pitot heat is on and turn on carburetor heat or jet engine anti-ice. Icing can be rapid at any altitude and cause almost instantaneous power failure and/or loss of airspeed indication.

(5) Establish power settings for turbulence penetration airspeed recommended in your aircraft manual.

(6) Turn up cockpit lights to highest intensity to lessen temporary blindness from lightning.

(7) If using automatic pilot, disengage altitude hold mode and speed hold mode. The automatic altitude and speed controls will increase maneuvers of the aircraft thus increasing structural stress.

(8) If using airborne radar, tilt the antenna up and down occasionally. This will permit you to detect other thunderstorm activity at altitudes other than the one being flown.

c. Following are some do's and don'ts DURING the thunderstorm penetration:

(1) Do keep your eyes on your instruments. Looking outside the cockpit can increase danger of temporary blindness from lightning.

(2) Don't change power settings; maintain settings for the recommended turbulence penetration airspeed.

(3) Do maintain a constant attitude; let the aircraft "ride the waves." Maneuvers in trying to maintain constant altitude increase stress on the aircraft.

(4) Don't turn back once you are in the thunderstorm. A straight course through the storm most likely will get you out of the hazards most quickly. In addition, turning maneuvers increase stress on the aircraft.

J. A. Ferrarese

J. A. FERRARESE
Acting Director
Flight Standards Service

APPENDIX 1. NSSL THUNDERSTORM RESEARCH

The National Severe Storms Laboratory (NSSL) has, since 1964, been the focal point of our thunderstorm research. In-flight conditions obtained from thunderstorm penetrations by controlled, especially equipped high performance aircraft are compared by the NSSL with National Weather Service (NWS) type ground-based radar and with newly developed doppler radar. The following comments are based on NSSL's interpretation of information and experience from this research.

a. Relationships between Turbulence and Reflectivity. Weather radar reflects precipitation such as rain and hail, not turbulence. It has been found, however, that the intensity level of the precipitation reflection does correlate with the degree of turbulence in a thunderstorm. The most severe turbulence is not necessarily found at the same place that gives the greatest radar reflection.

b. Relationships between Turbulence and Altitude. The NSSL studies of thunderstorms extending to 60,000 feet show little variation of turbulence intensity with altitude.

c. Turbulence and Echo Intensity on NWS Radar (WSR-57). The frequency and severity of turbulence increases with the radar reflectivity, a measure of the intensity of echoes from storm targets at a standard range. Derived gust velocities exceeding 2,100 feet per minute (classified as severe turbulence) are commonly encountered in Level 3 storms. In Level 2 storms, gusts of intensity between 1,200 and 2,100 feet per minute (classified as moderate turbulence) are encountered approximately once for each 10 nautical miles of thunderstorm flight.

d. Turbulence in Relation to Distance from Storm Core. NSSL data indicates that the frequency and severity of turbulence encounters decrease slowly with distance from storm cores. Significantly, the data indicates that within 20 miles from the center of severe storm cores, moderate to severe turbulence is encountered at any altitude about one-fifth as often as in the cores of Level 3 or greater thunderstorms. Further, the data indicates that moderate turbulence is encountered at any altitude up to 10 miles from the center of Level 2 thunderstorms. SEVERE TURBULENCE IS OFTEN FOUND IN TENUOUS ANVIL CLOUDS 15 TO 20 MILES DOWNWIND FROM SEVERE STORM CORES. Our findings agree with meteorological reasoning that THE STORM CLOUD IS ONLY THE VISIBLE PORTION OF A TURBULENT SYSTEM WHOSE UPDRAFTS AND DOWNDRAFTS OFTEN EXTEND OUTSIDE OF THE STORM PROPER.

e. Turbulence in Relation to Distance from the Storm Edge. THE CLEAR AIR ON THE INFLOW SIDE OF A STORM IS A PLACE WHERE SEVERE TURBULENCE MAY OCCUR. At the edge of a cloud, the mixing of cloudy and clear air often produces strong temperature gradients associated with rapid variations of vertical velocity. Tornadic activity is found in a wide range of spatial relationships to the strong echoes with which they are commonly associated, but many of the most intense and enduring tornadoes occur on the south to west edges of severe storms. The tornado itself is often associated with only a weak echo. Echo hooks and appendages are useful qualitative indicators of tornado occurrence but are by no means infallible guides. Severe turbulence should be anticipated up to 20 miles from the radar edge of severe storms; these often have a well-defined radar echo boundary. This distance decreases to approximately 10 miles with weaker storms which may sometimes have indefinite radar echo boundaries. THEREFORE, AIRBORNE RADAR IS A PARTICULARLY USEFUL AID FOR PILOTS IN MAINTAINING A SAFE DISTANCE FROM SEVERE STORMS.

f. Turbulence above Storm Tops. Flight data shows a relationship between turbulence above storm tops and the speed of upper tropospheric winds. WHEN THE WINDS AT STORM TOP EXCEED 100 KNOTS, THERE ARE TIMES WHEN SIGNIFICANT TURBULENCE MAY BE EXPERIENCED AS MUCH AS 10,000 FEET ABOVE THE CLOUD TOPS. THIS VALUE MAY BE DECREASED 1,000 FEET FOR EACH 10-KNOT REDUCTION OF WIND SPEED. This is especially important for clouds whose height exceeds the height of the tropopause. It should be noted that flight above severe thunderstorms is an academic consideration for today's civil aircraft in most cases, since these storms usually extend to 40,000 feet and above.

g. Turbulence below Cloud Base. While there is a little evidence that maximum turbulence exists at middle heights in storms (FL 200-300), turbulence beneath a storm is not to be minimized. This is especially true when the relative humidity is low in any air layer between the surface and 15,000 feet. Then the lower altitudes may be characterized by strong outflowing winds and severe turbulence where thunderstorms are present. Therefore, THE SAME TURBULENCE CONSIDERATIONS WHICH APPLY TO FLIGHT AT HIGH ALTITUDES NEAR STORMS APPLY TO LOW LEVELS AS WELL.

h. Maximum Storm Tops. Photogrammetric data indicates that the maximum height attained by thunderstorm clouds is approximately 63,000 feet. Such very tall storm tops have not been explored by direct means, but meteorological judgments indicate the probable existence of large hail and strong vertical drafts to within a few thousand feet of the top of these isolated stratosphere-penetrating storms. THEREFORE, IT APPEARS IMPORTANT TO AVOID SUCH VERY TALL STORMS AT ALL ALTITUDES.

i. Hail in Thunderstorms. The occurrence of HAIL IS MUCH MORE CLEARLY IDENTIFIED WITH THE INTENSITY OF ECHOES THAN IS TURBULENCE. AVOIDANCE OF MODERATE AND SEVERE STORMS SHOULD ALWAYS BE ASSOCIATED WITH THE AVOIDANCE OF DAMAGING HAIL.

j. Visual Appearance of Storms and Associated Turbulence Within Them. On numerous occasions, flights at NSSL have indicated that NO USEFUL CORRELATION EXISTS BETWEEN THE EXTERNAL VISUAL APPEARANCE OF THUNDERSTORMS AND THE TURBULENCE AND HAIL WITHIN THEM.

k. Modification of Criteria when Severe Storms and Rapid Development are Evident. During severe storm situations, radar echo intensities may grow by a factor of ten each minute, and cloud tops by 7,000 feet per minute. THEREFORE, NO FLIGHT PATH THROUGH SUCH A FIELD OF STRONG OR VERY STRONG

STORMS SEPARATED BY 20-30 MILES OR LESS MAY BE CONSIDERED TO REMAIN FREE FROM SEVERE TURBULENCE.

l. Extrapolation to Different Climes. General comment: Severe storms are associated with an atmospheric stratification marked by large values of moisture in low levels, relative dryness in middle levels, and strong wind shear. It is well known that this stratification of moisture permits excessive magnitudes of convective instability to exist for an indefinite period until rapid overturning of air is triggered by a suitable disturbance. Regions of the atmosphere which are either very dry or very moist throughout substantial depths cannot harbor great convective instability. Rather, a more nearly neutral thermal stratification is maintained, partially through a process of regular atmospheric overturning.

Desert Areas. In desert areas, storms should be avoided on the same basis as described in the above paragraphs. While nonstorm turbulence may, in general, be expected more frequently over desert areas during daylight hours than elsewhere, THE SAME TURBULENCE CONSIDERATIONS PREVAIL IN THE VICINITY OF THUNDERSTORMS.

Tropical-Humid Climates. When the atmosphere is moist and only slightly unstable through a great depth, strong radar echoes may be received from towering clouds which do not contain vertical velocities as strong as those of storms over the U.S. plains. Then it is a matter of the pilot being informed with respect to the general atmospheric conditions accompanying storms, for it is well known that PRACTICALLY ALL GEOGRAPHIC AREAS HAVING THUNDERSTORMS ARE OCCASIONALLY VISITED BY SEVERE ONES.

m. Use of Airborne Radar. Airborne radar is a valuable tool; HOWEVER, ITS USE IS PRINCIPALLY AS AN INDICATOR OF STORM LOCATIONS FOR AVOIDANCE PURPOSES WHILE EN ROUTE.

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ADVISORY CIRCULAR

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

SUBJECT: MAINTENANCE OF WEATHER RADAR RADOMES

1. PURPOSE. This advisory circular provides guidance material useful to repair facilities in the maintenance of weather radar radomes.

2. CANCELLATION. AC 43-202, dated 6/11/65, and AC 90-20, dated 11/12/64, are cancelled.

3. GENERAL. A radome is a covering whose primary purpose is to protect a radar antenna from the elements. It is a part of the airframe and, therefore, should have certain physical as well as electrical properties. Physically, a radome should be strong enough to withstand the airloads that it will encounter and it should be contoured to minimize drag. These properties vary with the shape, design speed, and size of the airplane on which it is to be installed. Electrically, a radome should permit the passage of the radar's transmitted signals and return echoes with minimum distortion and absorption. In order to do this, it should have a certain electrical thickness. The electrical thickness of a radome is related to the physical thickness, operating frequency, and the types of material and construction used. This relationship is defined by a number of complex mathematical equations which are of interest only to radome design engineers. These equations show that, for given physical properties, a radome should have a certain electrical thickness for a certain narrow range of operating frequencies. (This is the reason why C-band radomes will not give optimum performance with X-band radars and vice versa.) Also, a very small variation in physical thickness may cause a sizable variation in electrical thickness. Radar efficiency, definition, and accuracy of display depend upon a clear, nondistorted, reflection-free antenna view through the radome. Consequently, a radome should be precisely built for optimum performance.

4. RADOME CHARACTERISTICS. There are two general types of radomes, the "thin wall" and "sandwich" types. Thin wall radomes are considered to be thin relative to the wavelength of the radar. They are generally useful when the radar frequency is low enough to permit a skin thickness which will satisfy the structural requirements. Sandwich radomes consist of two

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or more plastic skins separated by a dielectric core. The core may consist of honeycomb plastic sections, hollow flutes, or foam plastic. The dielectric and separation of the skins will depend upon the wavelength of the radar frequency or frequencies.

5. RADOME DAMAGE. Probably the most frequent damage to radomes is holes in the structure caused by static discharges. These can be large holes that are readily apparent, or small pin holes that are almost imperceptible. Any hole, regardless of size, can cause major damage to a radome since moisture can enter the radome wall and cause internal delamination. If the moisture freezes, more serious damage may occur. If enough moisture collects, the radiation pattern will be distorted and the transmitted signals and return echoes seriously attenuated. Ram air through a hole can delaminate and break the inner surface of the radome and result in separation of the skins or faces of the material from the core, weakening the radome structure. Other types of damage are characterized as dents and scratches caused by impact with stones and birds and improper handling of the radome when it is removed for maintenance of the radar antenna. This type of damage is easily found by inspection.

6. MAINTENANCE.

a. High performance radar radomes are very precisely constructed and sometimes the slightest change in their physical characteristics, such as excessive layers of paint, can adversely affect radar system performance. All repairs to radomes, no matter how minor, should return the radome to its original or properly altered condition, both electrically and structurally. The performance of proper maintenance to precision radomes requires special knowledge and techniques and the use of proper tools and materials. An improper minor repair can eventually lead to an expensive major repair. A radome having undergone major repairs should be tested to ascertain that its electrical properties have not been impaired. The testing of radomes requires test equipment that usually is found only in repair facilities specializing in radome maintenance. Even minor repairs may affect one or all of the following:

(1) Transmissivity. Which is the ability of a radome to pass radar energy through it.

(2) Reflection. Which is the return or reflection of the outgoing radar energy from the radome back into the antenna and waveguide system.

(3) Diffraction. Which is the bending of the radar energy as it passes through the radome.

b. These electrical properties, when altered by improper repair, may cause loss of signal, distortion and displacement of targets, and can clutter the display to obscure the target. Poor radome electrical performance can produce numerous problems which may appear to be symptoms of deficiencies in other units of the radar system. The following are examples of improper repair:

(1) Use of wrong materials - not compatible with original radome materials.

(2) Patches of different thickness.

(3) Poor fabrication techniques.

(4) Nonvoid-free patches.

(5) Repairs overlapping.

(6) Holes plugged with resin, screws, metal, wood, and plastic plugs.

(7) Cuts or cracks simply coated with resin.

(8) Tape (including electrical tape) over hole or crack and covered with resin.

(9) Oversize patches.

(10) Too much or too little resin.

(11) Exterior coatings - too many coats, too thick, uneven thickness - metallic base paints.

(12) Filled honeycomb cells.

(13) Repairs made without removing moisture or moisture contamination from inside of radome wall.

(14) Abrupt changes in cross-sectional areas.

(15) Patches projecting above outside contour lines.

(16) Improper cure.

(17) Wrong size cells or density of honeycomb.

(18) Excessive overlap in honeycomb joints.

(19) Poor bonding of skin to core.

(20) Gaps in honeycomb core.

7. RECOMMENDATION. Both the physical and electrical properties of radomes should be given careful consideration during repair operations. These properties are carefully controlled during manufacture and should not be altered by improper repairs.

J. A. Ferrarese

J. A. FERRARESE
Acting Director, Flight Standards Service

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Washington, D.C. 20591

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